The Distribution and Reproductive Success of the Western Snowy Plover along the Oregon Coast - 2021

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Abstract

We monitored the distribution, abundance and productivity of the federally threatened Western Snowy Plover (*Charadrius nivosus nivosus*) along the central and south coast of Oregon from 2 April – 10 September 2021. We surveyed and monitored plover activity in a project area that included, from north to south, Sutton Beach, Siltcoos River estuary, the Dunes Overlook, Tahkenitch Creek, Tenmile Creek, Coos Bay North Spit, Bandon Snowy Plover Management Area, New River Habitat Restoration Area (HRA) and adjacent lands, and Floras Lake. Our objectives for the project area in 2021 were to: 1) estimate the size of the adult Snowy Plover population, 2) locate plover nests, 3) determine nest success, 4) implement nest protection as appropriate (e.g. ropes and signs), 5) monitor a sample of broods to determine brood fate and plover productivity, and 6) use cameras and observational data to document predator activity at nests.

We estimated the resident number of Snowy Plovers in Oregon at 604 individuals, the highest number since monitoring began in 1990. We monitored 712 nests in 2021. Overall apparent nest success was 27%. Nest failures were attributed to unknown depredation, unknown cause, unknown avian depredation, corvid depredation, mammalian depredation, harrier depredation, abandonment, one egg nest, gull depredation, wind/weather, overwashing, and infertility. We sampled 140 of 217 known broods that produced 162 fledglings and estimated 250 total fledglings. Overall brood success was 75%, fledging success was 44%, and based on the overall number of resident males, 0.62 chicks fledged per resident male.

Contents

Introduction

The Western Snowy Plover (*Charadrius nivosus nivosus*) breeds along the coast of the Pacific Ocean in California, Oregon, and Washington and at alkaline lakes in the interior of the western United States (Page *et al.* 1991). Loss of habitat, predation pressures, and disturbance have caused the decline of the coastal population of Snowy Plovers and led to the listing of the Pacific Coast Population of Western Snowy Plovers as threatened on March 5, 1993 (U.S. Fish and Wildlife Service 1993). Oregon Department of Fish and Wildlife (ODFW) lists the Western Snowy Plover as threatened throughout the state (ODFW 2009).

Oregon Biodiversity Information Center (ORBIC, formerly Oregon Natural Heritage Information Center) completed our 32nd year monitoring the distribution, abundance, and productivity of Snowy Plovers during the breeding season from Sutton Beach in Lane County to Floras Lake in Curry County on the Oregon coast. We define the project area as coastal habitat between Sutton Beach and Floras Lake (Figure 1). In cooperation with Federal and state agencies, plover management has focused on habitat restoration and maintenance at breeding sites, non-lethal and lethal predator management, and management of human related disturbances to nesting plovers. The goal of management is maintaining recent improvements in annual productivity, leading to a sustainable Oregon breeding population at or above recovery levels. Previous work and results have been summarized in annual reports that are available at https://inr.oregonstate.edu/biblio. Our objectives for the project area in 2021 were to: 1) estimate the size of the adult Snowy Plover population, 2) locate plover nests, 3) determine nest success, 4) implement nest protection as appropriate (e.g. ropes and signs), 5) monitor a sample of broods to determine brood fate and plover productivity, and 6) use cameras and observational data to document predator activity at nests.

Study Area

Due to the large plover population in the project area, in 2021 ORBIC intensively monitored plover activities, from north to south, at Siltcoos River estuary, the Dunes Overlook, North Tahkenitch Creek, the South Umpqua beach to the north spit at Tenmile Creek, Coos Bay North Spit (CBNS), Bandon Snowy Plover Management Area (SPMA), and New River Area of Critical Environmental Concern (ACEC) (Figure 1). Monitoring was limited at Sutton Beach, South Tahkenitch to the North Umpqua jetty (North Umpqua), South Tenmile, New River private land from the south end of Bandon SPMA to the New River ACEC, and Floras Lake. At intensively monitored breeding sites, we surveyed and monitored Snowy Plover activity along ocean beaches, sandy spits, ocean-overwashed areas within sand dunes dominated by European beachgrass (*Ammophila arenaria*), open estuarine areas with sand flats, a dredge spoil site, and several habitat restoration/management sites. Sites that were less intensively monitored had limited survey visits, with reduced nest monitoring and little to no sampling of broods. A description of each site occurs in Appendix A. For the purposes of this report and for consistency with previous years' data, we define Bandon Beach as the area from China Creek to the mouth of New River, and Bandon SPMA as all the state land from the north end of the China Creek parking lot south to the south boundary of the State Natural Area, south of the mouth of New River. We report summaries of the number of nests found outside intensive monitoring areas as reported to us by Oregon Department of Parks and Recreation (OPRD) and U.S. Fish and Wildlife Service (USFWS).

Methods

Window Surveys

Annual breeding season window surveys were coordinated by USFWS in mid-May. Breeding season window surveys were conducted at both currently active and historic nesting areas (Elliott-Smith and Haig 2007). All historic nesting areas were searched during the breeding window survey in 2021: Clatsop Spit, Camp Rilea, Necanicum Spit, Nehalem Spit, Bayocean Spit, Netarts Spit, Sand Lake Spits and Sitka Sedge State Natural Area (SNA), Nestucca Spit, Salmon River Spit, Salishan Spit, Agate Beach, Yaquina Point, South Beach State Park, Bayshore Spit, South Alsea Bay, Whisky Run to Coquille River, Sixes River, Cape Blanco to the Elk River, Elk River, Euchre Creek, Otter Point, Myers Creek to Pistol River, and Crissy Field.

Monitoring

Breeding season fieldwork was conducted from 2 April to 10 September 2021. Survey techniques, data collection methodology, and information regarding locating and documenting nests can be found in Appendix B. Some beach surveys, particularly to document brood success and to confirm fledglings, were conducted from a 4x4 vehicle using a window mounted scope. Some surveys conducted on the Dunes National Recreation Area (DNRA) and Sutton Beach were completed with a single observer. No other modifications to survey techniques were implemented in 2021.

We report three separate measures of adult population size: resident birds, the minimum number of birds present, and the breeding window survey. Resident plovers are defined here as any adult plover detected during the peak breeding period (between 15 April and 15 July). Plovers present during this period had the potential to attempt to nest. Not all plovers recorded during the summer are Oregon breeding plovers; some are only recorded early or late in the breeding season, suggesting that they are either migrant or wintering birds. These plovers are not included in the tally of resident plovers. The minimum number of Snowy Plovers present includes all adult birds observed within the project area during the field season (2 April through 10 September), and includes breeding birds, birds migrating through the area during that time, and wintering birds that may be present in the project area early or late in the season.

Most adults are banded and thus uniquely identifiable, while unbanded birds are difficult to accurately count because they move within and between sites. To avoid over counting unbanded birds, we recorded the number of unbanded plovers observed at each site within 10-day intervals from April through late July. We selected this period because it encompasses the period of maximum nesting effort and minimum movement between sites. For each 10-day interval we subtracted the number of adults that were subsequently banded during the breeding season and selected the 10-day interval with the highest remaining count. This number was added to our count of banded adults present, resulting in the minimum number of adults present. We also added this number of unbanded birds to our count of banded resident adults for a total estimate of resident birds. While this method may underestimate the actual number of unbanded plovers present, it provides a minimum number of unbanded plovers present (Castelein *et al.* 2001). We believe the number of resident plovers is the best estimate of the total breeding population because it only includes birds present during the peak breeding period.

We tallied the number of individual banded and unbanded plovers by sex recorded at each nesting area within the project area throughout the 2021 breeding season. We combined data from the north and south side of estuaries (Siltcoos, Overlook, and Tenmile) because individual plovers use both sides of these estuaries. We did not adequately survey South Tahkenitch to North Umpqua in 2021 and therefore were unable to determine the number of plovers using this area. Data from CBNS nesting sites were aggregated as plovers move freely between the beach and the nesting area. We separated data from Bandon SPMA, New River private lands, New River HRA, and Floras Lake because of different management at these sites, despite plovers frequently moving between these areas. The total number of individual plovers recorded at each site indicates the overall use of the site, including where plovers congregate during post-breeding and wintering. We also report the number of resident female and male plovers for each site, which indicates the relative level of nesting activity for each site. Because some birds used multiple sites within a season, a tally of the birds at each site does not reflect the total population size.

We calculated overall apparent nest success, the number of successful nests divided by the total number of nests observed, for all nests and for each individual site. The cause of nest failure was recorded when identifiable.

Lauten *et al*. (2016, 2017, 2018, 2019, and 2020) documents brood sampling techniques for the previous five years. During this time period we attempted to intensively monitor a sample of approximately 80% of all known broods to determine brood fate. Due to the continued increasing plover population and the limits of monitoring capabilities, in 2021 we revised our sampling scheme (Appendix C). In 2021, we reduced our sampling to a minimum of 50% of all known broods, and we reduced the number of sites that would have brood sampling. Specifically, we sampled broods at Siltcoos, Overlook, North Tahkenitch, North Tenmile, CBNS, Bandon SPMA, and New River ACEC. We reduced sampling efforts at Sutton Beach and Floras Lake because of small population sizes, and did not sample at South Tahkenitch, South Tenmile, and New River private lands. Sampling techniques were the same as previous years except for the reduced effort (Appendix C).

All known nests were monitored to determine fate and cause of failure. To track sampled broods, we banded chicks with a USGS aluminum band covered in color taped on the left leg and a colored plastic band covered in colored tape on the right leg. Most nesting adults that tended broods were already color banded. Due to the large number of banded plovers in the population, we did not attempt to band any additional unbanded adults. Some banded adults were trapped to replace existing band combinations. Trapping techniques are described in Lauten *et al.* 2005 and 2006 (Appendix B). We monitored broods and recorded brood activity or adults exhibiting broody behavior at each site approximately weekly (Page *et al.* 2009). Chicks were considered fledged when they were observed at least 28 days after hatching. Using the sample of banded chicks, we calculated brood success, the number of broods that successfully fledged at least one chick; fledging success, the number of chicks that fledged divided by the number of eggs that hatched from the sample; and the number of fledglings per sampled brood for each site. Using the estimate of the number of fledglings per sampled brood and the total number of known hatched nests, we calculated an estimated number of fledglings produced for each site. We used the number of estimated fledglings per site and the number of resident males to calculate the estimated number of fledglings per resident male for each site and the project area. See Appendix C for further details regarding calculation of the number of fledglings per male. We also calculated a breeding coefficient for all known nests (Colwell *et al.* 2017) that measures the level of productivity based on the number of fledglings produced per egg laid; high numbers of eggs laid indicate high effort at a particular site. If the numbers of fledglings produced is large compared to the number of eggs laid, the high breeding coefficient indicates that site was very productive. Alternatively, few fledglings relative to a high number of eggs laid results in a low breeding coefficient.

We compared plover productivity in 2021 to average post-predator management hatch rate, fledge rate and fledglings per male for each nesting area. We also compared the average pre-predator management hatch rate, fledge rate, and fledglings per male to the post-predator management averages to continue to evaluate the success of the current predator management actions. Means are reported +/- standard deviation.

We recorded banded adults and chicks that return to the project area in Oregon from previous seasons and calculated overwinter return rates for each group. Point Blue Conservation Science coordinates observations of banded birds throughout the range, and regularly reports observations of birds banded in Oregon that are sighted elsewhere. Overwinter return rates are the number of banded plovers (adults or first year birds) that returned to the project area in Oregon, divided by the number of banded adults or chicks observed the previous year. Banded plovers detected along the Oregon coast outside of the project area were not included in return rate calculations to maintain consistency with previous years' calculations.

Nest Failure

We monitored all nests we found until they were determined hatched or failed. Failed nests were carefully inspected for signs of cause of failure. Where evidence was present, we categorized failures as either depredations or non-depredated causes. If a failed nest was determined to be caused by predation, we attempted to determine the predator based on the evidence present. Failures caused by predators were generally categorized as corvid, harrier, gull, coyote, fox, skunk, unknown avian, mammalian, or unknown depredation. Failures not caused by predators were categorized as wind/weather, overwashed, human caused, abandoned, one egg nests (never completed clutch), infertile, or unknown cause.

We used Reconyx PC900 cameras (Reconyx Inc., Holmen, WI) and Bushnell Aggressor Trophy Cam HD (Bushnell Outdoor Products, Overland Park, KS) to observe predator activity at plover nests and identify causes of nest failure. Cameras were placed two to four meters from the nest, depending on local conditions (terrain, vegetation height). In general, we placed cameras as far from the nest as possible while keeping the nest visible in the camera's field of view. Cameras were camouflaged with a sand or brown-colored outer case or typical green hunter camouflage painting, and were installed as low to the ground as possible to avoid providing a perch for predators. Cameras were used at Siltcoos, Overlook, Tahkenitch, Tenmile, CBNS, and Bandon SPMA in 2021. We placed cameras at nests that were well beyond the view of the public to reduce the potential for camera theft, and to avoid creating an attractive nuisance.

Cameras employed a "no glow" infrared illumination system which eliminates glow or flash from the camera that can alert predators to its presence. Images taken during the day are in color; those at night are monochrome. Depending on the suite of suspected predators at a site, some cameras were set to operate 24 hours per day, taking one image every 60 seconds, and a burst of three to ten images every second when the motion sensor was triggered. Other cameras were set up to take one image per minute from just prior to dawn to just after dusk, and set to only motion sensor trigger at night. Bushnell cameras took only motion sensor triggered pictures. Predator activity at the nest triggered the motion sensor, but plovers were generally too small to trigger the cameras.

We placed cameras at active nests that were already being incubated (Snowy Plovers generally do not incubate until the clutch is complete). After cameras were installed, we ensured that plovers returned to the nest. Batteries and data cards were replaced approximately weekly. Cameras were typically left in place until the fate of the nest was determined. Upon visiting failed nests, we recorded the cause of failure based on evidence at the site, before looking at camera data. We compare cause of failure based on evidence at the nest site with the cause of failure as recorded by the cameras.

Lethal predator management was conducted at all active nesting areas by USDA Wildlife Services (USDA-APHIS-Wildlife Services 2021). ORBIC monitors reported causes of nest failure and daily predator observations to Wildlife Services (WS) staff.

Results

Window Surveys and Monitoring

During the May breeding window surveys, 481 plovers were observed in the project area, a substantial increase from 2020 and the highest window survey count since monitoring began in 1990. An additional 51 plovers were detected during the window survey at sites outside the project area including the Clatsop Spit, Nehalem Spit, Sand Lake and Sitka Sedge State Natural Area, Agate Beach, Yaquina Point, Bayshore Spit, and Otter Point (USFWS pers. comm.). The total of 532 plovers detected on the window survey in Oregon is the highest count ever for the Oregon coast, and the total of 624 for Recovery Unit 1 (Washington and Oregon) is also the highest count for a window breeding survey in this recovery unit. The annual breeding window survey count for the project area and total number of plovers present are in Table 1.

The increase in the minimum number of plovers present in the project area in 2021 was similar to the previous year, again resulting in the highest total since monitoring began in 1990 (Table 1). Of the minimum number of plovers present during the 2021 breeding season, 460 (75%) were banded. The number of unbanded plovers estimated by the 10-day interval method was 153, the highest estimate of unbanded plovers since monitoring began in 1990. During the breeding season we observed 237 banded males, 219 banded females, four banded adults of undetermined sex, 76 unbanded males, and 77 unbanded females.

Of the minimum number of plovers present in 2021, 310 plovers (51%) were documented nesting, lower than the mean percentage for 1993-2020 (77%). Due to sampling and the large number of nests, the decrease in the number of documented nesting plovers is not a reflection of fewer plovers attempting to nest but reflects a decrease in monitors positively identifying nest ownership. A minimum of 118 banded males and 85 banded females were positively identified on a nest, and a minimum of 107 unbanded adults (53 unbanded males and 54 unbanded females) nested. In 2021, 44% of banded adults were confirmed nesting. There was a total of 236 banded resident males and 211 banded resident females present during the 2021 breeding season (15 April – 15 July), and four plovers of undetermined sex were also residents. Using the minimum number of unbanded individuals estimated by the 10-day interval method, the minimum estimated Oregon resident plover population was 604. We believe this is the best estimate of the breeding population within the project area.

The overall plover population within the project area was more than triple the recovery goal set for the state (U.S. Fish and Wildlife Service 2007) and does not include birds that were present in Oregon outside the project area.

Overwinter Return Rate

Adult survival continues to be the most important parameter of population growth (Sandercock 2003, USFWS 2007, Dinsmore *et al.* 2010, Gaines 2019). Of the 466 banded adult plovers recorded in 2020, a minimum of 350 were recorded in 2021 in the project area. The overwinter return rate based on the minimum number of returning banded adult plovers was 75%, well higher than the 1994-2021 mean of 67% and higher than 2020 (71%). The adult male return rate was 79%, substantially higher than 2020 (71%, Lauten *et al*., 2020), and the adult female return rate was 73%, also higher than 2020 (71%, Lauten *et al.* 2020). Return rates indicate high over winter survival, the fourth consecutive year with above average adult return rates, resulting in an increasing plover population.

Of 231 banded fledglings produced in 2020 (Table 2), we observed 93 in the project area in 2021. The return rate was below the 2011-2021 average (Table 2) and lower than in 2020 (Lauten *et al*., 2020). Survival of hatch year 2020 (HY20) fledglings was higher than reported return rates because first year plovers that occupied other Oregon (ORBIC, OPRD, USFWS unpubl. data), Washington (USFWS, unpubl. data), and northern California (Elizabeth Fuecht, pers. comm.), beaches in 2021, but did not return to our project area, were not included in the calculated return rate. These additional HY20 plovers are important contributors to expanding plover populations at historic and new nesting locations in Oregon. Based on return rates, high adult survival was the main factor resulting in a higher plover population within the project area in 2021.

Of the returning HY20 birds, 52 (56%) were males and 41 (44%) were females. Forty of the HY20 returning plovers were confirmed breeding (43%), lower than 2020 (55%), however we sampled fewer broods and therefore confirmed fewer breeding adults.

During the 2021 season, we captured and rebanded three male and two female adult plovers with brood band combinations that needed to be updated to unique adult combinations. We did not band any unbanded adult plovers. We banded a total of 264 chicks, substantially fewer than in 2020 (n = 477).

Distribution

To show relative plover activity within our study area, we recorded total banded and unbanded adults and the number of resident plovers at each site (Table 3). The areas with the lowest plover activity are at the north and south ends of the project area. Due to limited surveys and monitoring at South Tahkenitch/North Umpqua area in 2021, we do not have an estimate of the number of plovers using this section of beach. There was a reduction in monitoring and sampling at Sutton Beach in 2021 for workload-related reasons, likely resulting in fewer plovers being detected in 2021 compared to 2020 (Table 3, n = 27 in 2020, Lauten *et al*., 2020). While there was a reduction in the total number of plovers detected at Sutton, the number of resident plovers was only slightly less than in 2020 suggesting that a relatively stable number of plovers continue to use this beach. Plovers continue to use most of the beach at Sutton, including hatching a nest and fledging chicks at Berry Creek, with other plover activity concentrated in the Sutton Creek area north to the Holman Vista trail.

The number of plovers using the Siltcoos estuary in 2021 was nearly identical to 2020 (Table 3, n = 76 and 62 in 2020, Lauten *et al*., 2020). Total plover numbers at Siltcoos are driven by detection of pre- and post-breeding plovers utilizing this site. In recent years the number of plovers overwintering at Siltcoos has declined slightly (ORBIC, USFWS unpubl. data), which has resulted in fewer total plovers detected at this site. However, the number of resident plovers has remained relatively stable for the past three years (Table 3, n = 67 and 62 for 2019 and 2020, Lauten *et al*., 2019 and 2020). The number of resident plovers at Overlook has remained stable for the past three years (Table 3, n = 115 in 2019, n = 112 in 2020, Lauten *et al*., 2019 and 2020). There was a slight increase in the total number of plovers detected at Overlook in 2021 (Table 3, n = 125 in 2020, Lauten *et al*., 2020); this was likely the result of high nest failure in the area in 2021 resulting in renesting plovers moving between sites searching for alternative nesting locations. Tahkenitch also had stable population numbers, with total and resident plover numbers nearly identical to 2020 (Table 3, n = 100 and 90 in 2020, Lauten *et al*., 2020).

The total number of plovers detected at Tenmile was identical to 2020 (Table 3, Lauten *et al*., 2020). There was slight increase in resident plovers in 2021 compared to 2020 (Table 3, n = 82 in 2020, Lauten *et al*., 2020). The increase in resident plovers may be related to good nest success at Tenmile and poor nest success at Overlook and Tahkenitch, resulting in some plovers successfully renesting at Tenmile. Detection of plovers on the Dunes NRA indicates contiguous habitat from Tenmile to Siltcoos that is fully occupied by the plover population, and plovers will move between these sites searching for potential nesting locations.

CBNS had slightly less but similar numbers of plovers in 2021 compared to 2020 (Table 3, n = 151 and 144 in 2020, Lauten *et al.* 2020). Plovers continue to use the beach north of the FAA towers south to the jetty for nesting, and the entire nesting area is occupied with nesting plovers. The Bandon SPMA had similar but slightly higher numbers of plovers in 2021 compared to 2020 (Table 3, n = 123 and 104 in 2020, Lauten *et al*., 2020). Plovers continue to nest on the beach north of China Creek south to the south end of the Bandon SPMA. There were similar numbers of plovers at both New River private land and Floras Lake in 2021 compared to 2020 (Table 3, Lauten *et al*., 2020), while the New River HRA had a slight increase in plover numbers in 2021 compared to 2020 (Table 3, Lauten *et al*., 2019). Most plover activity at the south end of the project area along New River is concentrated on the HRA both north and south of the Croft Lake breach. Despite an increase in total number of plovers detected in the project area (Table 1), Table 3 data indicate that the nesting areas appear to have relatively stable nesting population sizes. This may indicate that the nesting areas have reached carrying capacity, and while the population continues to grow, there is nest saturation at the main nesting sites in the project area. Plovers nesting on the north coast from Columbia River to Waldport, as well as plovers detected south of the Floras Lake during the breeding season, indicate that plovers have and will continue to seek new nesting areas as the traditional project area nesting sites remain at or near carry capacity. Because plovers moved between sites and attempted to nest at more than one location, the total number of plovers in Table 3 is higher than the actual population estimate.

In 2021, plovers were documented nesting for the fourth consecutive year in every coastal county in Oregon. Nesting plovers were at Clatsop Spit in Clatsop Co., and Nehalem Bay State Park and Sitka Sedge State Natural Area and Sand Lake in Tillamook Co. In Lincoln Co., nests were found at Agate Beach, Yaquina Bay State Park, South Beach State Park, Beachside State Park, Collins Creek, Driftwood State Park, Fox Creek, Bayshore Spit, Sandpiper Village, and Sunset Street. (OPRD, unpublished data, USFWS, pers. comm.). Similar to the past several years, plovers have continued to expanded their nesting efforts within the project area. Plovers continue to occupy and nest at Berry Creek and Sutton Creek at Sutton Beach (Figure 2); Tahkenitch Creek estuary to North Umpqua (Figures 6 and 7); South Umpqua from the vicinity of the second parking lot south to the North Tenmile spit (Figure 8); north of the FAA towers on South Beach, CBNS (Figures 10 and 11); north of China Creek at Bandon Beach, Bandon SPMA (Figures 12 and 13); and along the New River HRA from the north end to Clay Island breach (Figure 14). Plovers should be expected to continue to occupy available habitat along the entire coast of Oregon and may be found at unexpected locations with sufficient habitat along the coast.

Nest Activity

Table 4 shows the number of nests located during the 2021 nesting season in our study area (Figures 2-15). We found 62 more nests than in 2020, but 63 fewer nests hatched (Lauten *et al*., 2020). Overall nest success in 2021 was well below the average (Tables 5 and 6) and well below the average of the last 10 years ($\bar{x}$ = 40%). Nest numbers increased at North and South Siltcooos, North and South Overlook, North Tahkenitch, Bandon SPMA, and New River HRA. There was a decline in nest numbers at Sutton Beach, North and South Tenmile, and Floras Lake. The increase in nest numbers, particularly at Overlook and North Tahkenitch as well as Bandon SPMA, were due to an increase in nest failure, resulting in more renesting attempts. At Tenmile, particularly the north side, the decline in nest numbers was due to increased nest success and therefore fewer renest attempts. Sutton Beach was not as intensively monitored and therefore the decline in nest numbers may be a function of decreased monitoring. The decline in nest numbers at Floras Lake was due to fewer plovers and nest attempts at this site, with an increase in nest attempts further north on the New River HRA.

The first nests were initiated about 16 March (Figure 16). Nest initiation increased through the end of April, declined, and then increased to the peak. Peak nesting occurred during two consecutive time periods in June: 10 June to 19 June and 20 June to 29 June, about a month later than 2020 (Lauten *et al.* 2020). The last nest initiation occurred on 28 July.

An additional 108 nests were found outside our study area (Table 7). Only 6 of these nests were known to hatch, but because these nests did not receive the same level of monitoring, their success cannot be compared to nests within the study area.

Nest Failure

Predators were the main cause of nest failure and were responsible for 73% of nest failures (Table 8), higher than in 2020 (62%, Lauten *et al.* 2020). Common Ravens (*Corvus corax*) were the most commonly identified predator (26% of known depredations), however there were fewer raven depredations in 2021 compared to 2020 (n = 68, Lauten *et al*., 2020) due to a large decline in raven depredations at Tenmile (Table 8, n = 39 at Tenmile in 2020, Lauten *et al*., 2020). Ravens were responsible for 55 of the 57 corvid depredations (96%). The number of depredations due to Northern Harrier (*Circus hudsonius*) increased from nine nests in 2020 to 32 nests in 2021 (Table 8, Lauten *et al*., 2020), and harriers were likely also responsible for some, and possibly a large portion, of the 47 unknown avian depredations that were recorded on the Dunes NRA sites. While evidence clearly indicates an avian predator was the cause of these nest failures, tracks at the nest were inconclusive to determine whether they were corvid or harrier depredations. Fourteen nests at Bandon SPMA were known to have been depredated by a Western Gull (*Larus occidentalis*); only one nest was depredated by a gull in 2020 (Lauten *et al*., 2020). There were more coyote (*Canis latrans*) depredations in 2021 (n = 38) than all mammal depredation in 2020 (Table 8, n= 32 for 2020, Lauten *et al*., 2020). There has been an increasing trend in coyote depredation on the Dunes NRA since 2019 (Lauten *et al*., 2019 and 2020); 2021 had the highest coyote caused nest failures since monitoring began in 1990. Gray fox (*Urocyon cinereoargenteus*) caused five failures at Bandon SPMA, the first time gray fox caused more nest failures than red fox (*Vulpes vulpes*) (Table 8). Red fox numbers appear to be diminishing along the Bandon and New River area, due to persistent efforts to remove them. In 2021 red fox were mostly absent from Bandon SPMA and on the north side of the Croft Lake breach. Skunks (*Mephitis* sp.) and raccoon (*Procyon lotor*) each caused one depredation (Table 8).

Corvids continue to be the most commonly identified nest predator on the study area (see previous reports at https://inr.oregonstate.edu/biblio). In 2020 Common Raven depredations were particularly high at Tenmile; in 2021 only two nests were positively identified as raven depredations at Tenmile. The decline in raven activity at Tenmile was due to increased efforts to remove them early in the season by WS. Unfortunately, raven activity at Overlook and Tahkenitch was persistent throughout the 2021 season resulting in 28 more nest failures due to ravens compared to 2020 (Table 8, Lauten *et al*., 2020). As in 2020, the data shows that failure to remove problematic ravens results in poor nest success and productivity. Removal of corvids at all sites remains high priority.

Coyote depredations on the Dunes NRA continue to increase suggesting that the resident coyotes are responding to increased density of nesting plovers and a reliable food resource. Ravens and harriers continue to be the main cause of nest failures because they are likely more efficient at locating plover nests, however coyotes appear to be increasingly targeting plovers as density of plovers increases. WS has done limited targeting of coyotes on the Dunes NRA in the past few years, and will continue efforts to remove coyotes with the goal of reducing predation pressure on incubating nesting plovers. See the APHIS-Wildlife Services report for details concerning predator management (USDA-APHIS-Wildlife Service 2021).

In 2021 there was persistent Northern Harrier activity at Siltcoos, Overlook, Tahkenitch, Tenmile and CBNS. At CBNS, one pair of harriers were noted nesting on the plover nesting area early in the season, and the first documented harrier nest depredation occurred on 6 April. Additional harriers were also noted hunting over the CBNS nesting area and nesting nearby. In early April we documented fairly low nest initiation on the nesting area at CBNS, and plovers were flocking on the beach north of the FAA towers. This is the first time we have documented plovers flocking and roosting far north of the nesting area early in the season. We believe it is likely that the persistent harrier presence on the nesting area, with displaying and nest building as well as hunting behavior, may have pushed plovers to the beach and further north than is typical. WS found three harrier nests at CBNS, two of which were removed before incubation, and one that was abandoned after discovery. In addition, the pair of harriers nesting on the plover nesting area were lethally removed. Nest success was much improved at CBNS once the harriers were removed. We continued to document at least one additional harrier occasionally hunting over the HRA, but only had one more harrier caused nest depredation after the two harriers were removed. Data from CBNS continues to indicate that presence of harriers can have a negative effect on nest success, brood success, fledgling success, and fledglings per brood (Figures –17-20), and removal of harriers has a positive effect on these reproductive parameters. At Tenmile, harriers depredated at least four nests on the south side of the estuary (Table 8). Due to reduced monitoring at this site, it is possible harriers may have caused more nest failures. Harriers were also documented depredating nests at Siltcoos, Overlook, and Tahkenitch (Table 8). At Overlook harriers were present all season with at least 13 nests failed due to harriers (Table 8) and likely more as many nests either lacked any evidence of cause of failure or lacked enough evidence to positively identify the cause other than avian. The annual documentation of failed nests due to harriers as well as the widespread harrier activity at most of the nesting sites clearly indicate that harriers are a normal, annual predator of plover nests, chicks, and adults, and management of harrier impacts is important to help maintain and sustain plover nesting success.

In 2020 we discussed that Great Horned Owls (*Bubo virginianus*) were potentially contributing to low reproductive output at Bandon SPMA, especially on the New River spit (Lauten *et al*., 2020). In 2021 we noted little owl activity at the New River spit, and we did not have evidence to suggest that owls were causing any nesting or brooding failures. In 2021 we also had low raven and red fox activity, yet we had persistent nest failure with little evidence of the cause (mostly due to poor weather conditions). Eventually we documented gull tracks at failed nests, and placed cameras to confirm gull depredation. Camera images revealed an adult Western Gull, and about this time we began to see an adult Western Gull cruising over the middle of the dunes, circling around, and actively dropping down hunting for food. We witnessed the gull circle over and drop down on chicken eggs that WS had set to trap the bird. Although it was difficult to identify the problematic individual, and it evaded WS trapping efforts, WS ultimately removed an adult Western Gull that went after egg bait, and once this gull was removed nest success improved dramatically. Unfortunately, the gull was removed late in the season after most plovers stopped laying eggs, resulting in very few nests successfully hatching, particularly on the New River spit side of Bandon SPMA. Bandon SPMA is the only site where gulls have been a nest predator over the last ten years. We are hopeful that the removal of this gull will have benefits in the coming year, as it appears that it is individual gulls who learn to hunt plover nests, and their removal usually results in improved nest success.

The highest cause of nest failure was unknown depredation (Table 8). The number of nests that failed to unknown depredations was much higher than in 2020 (n = 97, Lauten *et al*., 2020), as was the number of nests that failed to unknown cause (Table 8, n = 60 for 2020, Lauten *et al*., 2020). The main reason for unknown outcomes was windy and/or wet weather conditions that wiped away tracks. In addition, reduced coverage at some nesting sites results in longer time periods between some nest visits which increases the likelihood that evidence at the nest site will be removed. For unknown depredations, we determined that a predator was the cause of the failure, but there was a lack of evidence as to which predator. Our samples from each site suggests the proportion of predators responsible for these unknown depredations. On the Dunes NRA, known nest failures were caused by ravens, harriers, and coyotes, and therefore the large number of unknown depredations in this area were the result of these three predators. At CBNS, early in the season unknown depredations were likely caused by both ravens and harriers. Once ravens were successfully removed from this site, harriers were the likely the main cause of failure. At Bandon SPMA, the large number of unknown depredations were most likely caused by the gull. The gull left very little evidence at the nest site, as it would land at the nest bowl, swallow the eggs whole within seconds, and quickly fly off. The New River spit is open and susceptible to very windy conditions and shifting sands, therefore the gull tracks at depredated nests would be erased quickly, resulting in many unknown depredations. At New River HRA, the main cause of failure is likely the persistent raven activity from the nearby ranches.

Nest failures are categorized as due to unknown cause because there is no evidence at the nest site of what may have happened. These nests frequently are in places where windy conditions drastically change the landscape, overwashing could have occurred, predation may have occurred before or after wind or overwashing, or human activity may have contributed to the outcome. The largest number of nests failed to unknown causes come from Bandon SPMA (Table 8) where windy conditions, in combination with a fair amount of human activity, especially on the Bandon Beach side, results in high numbers of unknown-cause failures. Currently there is also little available habitat along the foredune, where plovers are nesting in fairly high densities, which results in shifting sandy conditions, and close interaction with recreational activity.

We placed Reconyx and Bushnel cameras at 36 nests in 2021 to document nest predators. At eight nests the camera failed due to malfunction; five of these hatched and 3 were depredated (all unknown cause). A total of 18 nests hatched; overall nest success for camera nests was 50%, higher than the overall apparent nest success for all nests (Table 5), suggesting the use of cameras did not negatively affect nest success. A total of 18 nests failed.

Two nests were abandoned, never having been attended. One nest was windblown. Fifteen nests failed to depredation. Three nests failed to harrier, three to raven, and two to coyote and gull. Five other nests failed to depredation but the camera failed to capture any images of the predator. While we did not determine any new predator information from cameras in 2021, we were able to confirm that the gull was an adult Western gull. We intend to continue to use cameras where they are feasible, as time is available, and where better documentation of the cause of nest failure is needed, as long as there is no evidence predators are targeting nests with cameras.

Productivity

We sampled 140 broods from the 195 nests that were known to have hatched and an additional 22 broods from undiscovered nests (65%), 66 fewer broods than we sampled in 2020 (Lauten *et al*., 2020). The sample produced 162 fledglings (Table 9). The overall fledging success based on the sample broods (Table 9) was slightly lower than the post-predator management average (Table 10). The overall brood success rate of sampled broods (Table 9) was near the post-predator 2004 – 2021 average ($\bar{x} = 74\%$ +/- 7). Using the data from sampled broods, we estimated the total number of fledglings for each site by multiplying the number of fledglings per sampled brood by the total number of broods hatched at each site. Table 11 shows the estimated total number of fledglings produced in 2021. We calculated the number of fledglings per male for each site using the number of resident males from Table 3 (Table 12). The mean number of fledglings per resident male for the project area was well below recovery goals and below the mean post-predator management average (Table 10). We report these mean fledglings per male by site for comparison with previous years, but because the number of resident males reported by site double counts birds that occur at multiple sites and may include males that were present but did not attempt to nest, the resulting overall mean number of chicks fledged per resident male is biased low. In 2021 the estimated number of fledglings was 250 (Table 11), and the estimated number of resident males was 312. The number of fledglings per resident male based on these numbers was 0.80, higher than our reported mean number of fledglings per resident male by site (Table 12) but lower than the number of fledglings per sampled brood (Table 9). We believe the estimate of productivity based on the number of fledglings produced per sample brood (1.16, Table 9) is a good estimate of reproductive output of successful males within the project area. However, based on the total male population size with the project area (ca. = 312) and the estimated number of fledglings produced (Table 11), overall productivity was below recovery goals of 1.00 fledgling per male.

We used the breeding coefficient, the number of fledglings produced per number of eggs laid, as an alternate assessment of the overall productivity of each nesting site (Table 9, Lauten *et al.* 2017, Colwell *et al.* 2017). The breeding coefficient is a measure of productivity based on effort (eggs laid). Any site with a breeding coefficient of 0.20 and above was relatively successful for the amount of effort, while sites with a breeding coefficient below 0.15 are generally not very productive for the amount of effort.

Sutton

We documented fewer nests at Sutton Beach in 2021 than the previous five years (Table 4), but this is likely a result of decreased monitoring effort at this site in 2021. Nest success in 2021 (Table 5) was slightly higher than the average for this site ($\bar{x} = 20\%$); nest success at Sutton Beach is historically low due to windy conditions and persistent raven activity. Three broods were used in the sample (Table 9); only one was successful and it fledged two chicks. There were a total of five known broods from Sutton Beach and they produced an estimated three fledglings, lower than the previous three years (Table 11). The hatch rate was higher than the previous two years (Lauten *et al*., 2019 and 2020) and was above the post predator management average (Figure 21). Fledging success was lower than the previous two years (Lauten *et al*., 2019 and 2020) and slightly above the post predator management average (Figure 22), but the sample was very small. The number of fledglings per resident male was much lower than 2020 (Lauten *et al.* 2020) and equal to the post predator management average (Figure 23), but the average at Sutton Beach is the lowest for any site within the project area. The number of fledglings produced was lower than the previous three years (Table 11). Sutton Beach historically produces low number of fledglings (Table 11) and the breeding coefficient continues to be low (Table 9) indicating poor reproductive output for the effort.

Siltcoos

There were 13 more nests at Siltcoos in 2021 compared to 2020 (Table 4). Nest success on both sides of the river was higher than in 2020 (Table 5, Lauten *et al*. 2020), with the north side well above average ($\bar{x} = 37\%$) and the south side slightly above average ($\bar{x} = 46\%$).

The hatch rate at Siltcoos in 2021 was much higher than in 2020 (Lauten *et al*., 2020) and above the post-predator management average (Figure 21). There were more broods on the north side in 2021 compared to 2020 but similar numbers of broods on the south spit (Lauten *et al.* 2020). The north side produced twice as many fledglings in 2021 compared to 2020 (Lauten *et al*., 2020) while the south side produced similar numbers of fledglings (Table 11). Overall fledging success was very good and at the post-predator management average (Figure 22). The number of fledglings per sampled brood was very good for both sides of the river (Table 9), and the overall number of fledglings per resident male was near the post-predator management average for this site (Figure 23, Table 12). The breeding coefficient on both sides of the river was high and indicates good productivity for this site (Table 9). The north side had overall improved productivity in 2021, and for the second consecutive year, Siltcoos was very productive.

Overlook

There was a large increase in the number of nests at Overlook in 2021 compared to 2020 (Table 4) due to persistent predator pressure resulting in poor nest success and many renesting attempts (Table 5). Nest success at both North and South Overlook was extremely low and well below average (Table 5, $\bar{x} = 44\%$ and $\bar{x} = 41\%$, respectively).

The hatch rate at Overlook in 2021 was nearly 30 points below average (Figure 21) resulting in 40 fewer broods from these sites (Table 9, Lauten *et al*., 2020). Due to the poor nest success and reduction in broods, there were 53 fewer fledglings produced at Overlook in 2021 compared to 2020 (Table 11). Brood success was also impacted, with the lowest brood success rates for all sites except Sutton Beach (Table 9). Fledging success was well below the post predator management average for this site (Figure 22). The number of fledglings per resident male was well below the post-predator management average (Figure 23, Table 12). Due to the high number of nests, large numbers of eggs laid, and low fledgling productivity, Overlook had extremely low breeding coefficients indicating very poor productivity for this site that harbors large numbers of plovers (Table 9).

Tahkenitch

There was an increase in the number of nests at North Tahkenitch in 2021 (Table 4) due to low nest success and subsequent renesting attempts. Limited monitoring at South Tahkenitch documented six nest attempts in 2021 (Table 4) and all failed. Nest success at North Tahkenitch was very poor (Table 5) and well below the average for this site ($\bar{x} = 41\%$).

Due to high rates of nest failure, the hatch rate at Tahkenitch in 2021 was well below the post-predator management average (Figure 21) resulting in 22 fewer broods in 2021 compared to 2020 (Lauten *et al*., 2020). The fledging success rate was also well below post predator management average (Figure 22), suggesting predation pressure likely effected broods also. The number of fledglings per resident male was well below the post predator management average (Figure 23). The number of fledglings produced was substantially lower than in 2020 (Table 11), and the lowest since 2013. At South Tahkenitch, all known nests failed, and there was no sample of broods at this site. Due to the large number of nests and eggs at North Tahkenitch and the low fledgling productivity, the breeding coefficient was very low indicating very poor productivity for this important breeding site (Table 9).

In 2019 and 2020, Siltcoos, Overlook, and Tahkenitch produced a combined 145 and 142 fledglings respectively (Table 11). In 2021 the estimated number of fledglings for this area was 67, less than half of the previous two years. Predation pressure by ravens, harriers and coyotes lead to high nest loss, resulting in fewer broods and poor reproductive output.

Tenmile

North Tenmile had fewer nests in 2021 than in 2020 (Table 4) due to higher nest success (Table 5) resulting in more hatched nests and twice the number of broods as in 2020 (Lauten *et al*., 2020). The higher nest success was due to a reduction in raven activity. Nest success at North Tenmile was much higher than in 2020 (Lauten *et al*. 2020) and just below average for this site ($\bar{x}$ = 43%). There was a slight reduction in the number of nests at South Tenmile (Table 4), but this was likely due to reduced monitoring at this site. Nest success at South Tenmile was only slightly higher than in 2020 (Table 5, Lauten *et al*., 2020) and was only half the average for this site ($\bar{x}$ = 48%). While there was reduced monitoring and no brood sampling at South Tenmile, harriers were the main cause of known nest failure, and likely contributed to low productivity at this site. Due to the reduction in predator activity at North Tenmile, 40 more fledglings were produced in 2021 compared to 2020 (Table 11). We estimated the number of fledglings at South Tenmile based on sampled data from North Tenmile.

The overall hatch rate at Tenmile was below the post-predator management average (Figure 21), however broods that did hatch had very good fledging success rate (Figure 22). The number of fledglings per resident male was well above average (Table 12, Figure 23). Based on the sample at North Tenmile, the breeding coefficient in 2021 (Table 9) was substantially higher than 2020 (Lauten *et al*., 2020), indicating much improvement in productivity and successful reproductive output.

The Dunes NRA produced 138 fledglings in 2021, lower than the previous two years (186 fledglings in 2019 and 171 in 2020, Table 11). Siltcoos and North Tenmile produced the majority of the fledglings (74%). Overlook and Tahkenitch typically contribute substantially to annual productivity but did not in 2021. Better reproductive output at these important nesting sites is essential to sustaining the plover population.

Coos Bay North Spit

The total number of nests at CBNS in 2021 was slightly less than in 2020 and 2019 (Table 4). There were more nests on the HRAs in 2021 compared to 2020 (Lauten *et al*., 2020) due to less predator pressure from Northern Harriers and therefore higher nest success on the HRAs in 2021 (Table 5). Due to higher nest success on the nesting area in 2021, there were fewer nests on the beach (Table 4). Overall nest success in 2021 was similar to the previous two years (Table 5, Lauten *et al*., 2019 and 2020). Nest success on the HRAs was much higher than in 2020 (Lauten *et al*., 2020) and above average ($\bar{x}$ = 50%). Nest success on South Spoil was also higher than in 2020 (Table 5, Lauten *et al*, 2020) but well below average ($\bar{x}$= 60%). Nest success on South Beach was much lower than in 2020 (Table 5, Lauten *et al*., 2020) and well below average ($\bar{x}$= 60%). Nest success at CBNS was mostly impacted by ravens and harriers early in the season (Table 8); once both species were removed nest success improved, particularly on the nesting area. Data indicate that removal of harriers has a positive impact on plover productivity (Lauten *et al*., 2020, Figures 17-20). Similar numbers of nests hatched in 2021 compared to 2020 (Table 5, Lauten *et al*., 2020), and these broods produced the same estimated number of fledglings (Table 11). While the overall plover population continues to grow (Table 1), the number of nests at CBNS has remained relatively stable since 2015 (Table 4), suggesting that plover numbers and nest density are at carrying capacity for this site.

The hatch rate at CBNS in 2021 was the same as the post-predator management average (Figure 21). Fledging success was below average for this site (Figure 22), but still at recovery goals. The number of fledglings per resident male was well below average for CBNS (Figure 23), however this number may be biased low due to the large number of male plovers that visit this site during the residency season, and are thus counted as breeding residents, but may not have attempted nesting.

While we traditionally separate South Spoil from the HRAs for data analysis, the HRAs surround South Spoil and the nesting area is contiguous. In 2021 we only sampled one brood from South Spoil, therefore we pooled this brood with the sample from the HRAs. We sampled eight more broods on the nesting area in 2021 compared to 2020 (Table 9, Lauten *et al*., 2020). Brood success was higher in 2021 compared to 2020 while fledging success and the number of fledglings per brood were nearly the same as 2020 (Table 9, Lauten *et al*., 2020) resulting in a slight increase in the number of fledglings produced on the nesting area (Table 11). Productivity as measured by the breeding coefficient was much higher in 2021 compared to 2020 (Table 9, Lauten *et al*., 2020), indicating that plovers were much more productive for the effort. The increase in productivity on the nesting area was likely due to the removal of two Northern Harriers in 2021. Data from CBNS indicates that when harriers are present, reproductive output of plovers is depressed (Figures 17-20). There was a much smaller sample from South Beach in 2021 compared to 2020 (Table 9, Lauten *et al*., 2020) due to fewer nests, and all reproductive parameters were much higher in 2021. The breeding coefficient was also very high, indicating good output for the effort. In 2020 (Lauten *et al*., 2020) we documented both recreational vehicle use of South Beach and degradation of habitat on the beach due to beachgrass and western movement of the foredune were likely affecting both nest and brood success. In 2021 we continued to note regular vehicle violations of the closed area, including repeated driving high on dry sand, including behind ropes and signs. Loss of habitat has resulted in a narrowing of available nesting and brooding areas on the beach, and has reduced any buffer between recreational activity on the beach and nesting and brooding plovers. The loss of habitat and illegal recreational vehicle use and violations of the closed area are detrimental to plover productivity.

Bandon SPMA

There were 14 more nests at Bandon SPMA in 2021 compared to 2020 (Table 4). The increase in nest numbers was due to nest failure, as the number of plovers at this site was similar to 2020 (Table 3, Lauten *et al*., 2020). There were 46 more failed nests in 2021 compared to 2020 (Table 8, Lauten *et al*., 2020) resulting in an increase in renest attempts. Nest success was extremely low (Table 5) and well below the average for this site ($\bar{x}$ = 40%). The poor nest success was partly the result of a Western Gull that was very successful at targeting plover nests. In addition, the large open spit south of the New River mouth was cleared of all woody debris by overwashing during the previous winter. Due to windy summer conditions, nests on the open spit were susceptible to windblown sand and burial. On the Bandon Beach side of the river, loss of habitat due to lack of habitat maintenance has resulted in a very narrow dry sand section of beach in front of the foredune. Plovers nested in fairly high densities along the foredune and were susceptible to gray fox that consistently hunted this narrow and relatively short section of beach. Due to the predation pressure and windy conditions, nest success at Bandon Beach was 19%, much lower than 2020 (33%, Lauten *et al*., 2020), and nest success on the New River spit was only 7%, also much lower than 2020 (35%, Lauten *et al*., 2020). Bandon Beach did produce a higher number of fledglings in 2021 compared to 2020, while the New River spit produced just six fledglings in 2021, much lower than 2020 (Table 11).

The hatch rate at Bandon SPMA was well below the post-predator management average (Figure 21) but the fledging success rate was above average (Figure 22). Fledging success at Bandon Beach was 42%, and the fledging success rate on the New River spit was also 42%. These fledging success rates indicated that if a nest hatched, plovers were relatively successful at raising chicks. This was likely due to the main predator, Western Gull, targeting plover eggs and not plover chicks, and the lack of ravens and red fox which tend to have a detrimental effect on chicks as well as eggs. Due to the high number of males utilizing this site and the low number of successful nests, the number of fledglings per resident male was well below average (Figure 23). The high numbers of eggs laid at the SPMA and the low number of fledglings resulted in a very low breeding coefficient (Table 9), indicating very poor productivity for the effort. In 2020, Lauten *et al*. (2020) discussed the presence of Great

Horned Owls at this site and the potential negative impact they may have had on nesting plovers. In 2021 we had very limited evidence of Great Horned Owl activity, and therefore WS took no action to remove any owls.

New River

We found three nests south of the Bandon SPMA boundary area on New River private land in 2021 (Figure 13, Table 4). Two nests failed to depredation and one nest successfully incubated for over 28 days but was infertile. We did note two broods from undiscovered nests along this section of beach. Both of these broods successfully fledged one chick each, however we did not sample in this area and therefore do not have any estimates of reproductive parameters.

We found twice as many nests on the New River HRA in 2021 compared to 2020 (Table 4). There was a slight increase in plover numbers at this site (Table 3, Lauten *et al*., 2020), but the number of nests that hatched in 2021 was similar to 2020 (Table 5, Lauten *et al*., 2020) indicating that the increase in nest numbers was a combination of more plovers and renesting attempts. Plovers utilized the entire HRA, nesting from just north of the HRA to Clay Island breach, with most of the nesting activity concentrated on the north and south side of Croft Lake breach (Figure 14). While nest success was much lower than in 2020 (Table 5, Lauten *et al*, 2020) and below average ($\bar{x}$ = 51%), the number of nests that hatched was nearly the same. Brood success was excellent and similar to 2020 (Table 9, Lauten *et al*., 2020). Fledgling success and the number of fledglings per brood were also very good, but lower than in 2020 (Table 9, Lauten *et al*., 2020). The breeding coefficient was lower than in 2020 (Table 9, Lauten *et al*., 2020), but still indicated good productivity for the effort. New River HRA has traditionally had relatively poor reproductive parameters due to persistent red fox and raven activity from the adjacent ranches east of the river. In 2021 raven activity was consistent, particularly south of the Croft Lake breach. Red fox were present mostly on the south side of the breach, with the breach likely responsible for limiting their movements north. Despite the persistent predator pressure at New River HRA, plovers were successful for two consecutive years at this site.

The hatch rate was below the post predator management average for this site (Figure 21), but the fledging success rate was slightly above the post predator management average (Figure 22). The number of fledglings per resident males was below the post-predator management average (Figures 23).

Floras Lake

We found fewer nests at Floras Lake in 2021 compared to the previous two years (Table 4). Two of the nests were successful (Table 5) resulting in above average nest success ($\bar{x}$ = 56%). We were able to monitor both broods; each successfully fledged a chick (Table 9). Productivity parameters from this site in 2021 were very good, resulting in a very good breeding coefficient, indicating good productivity for the effort (Table 9).

Summary

In 2021, overall nest success was well below the post-predator management average (Table 5, $\bar{x}$ = 42%) and below the level we believe is needed for a sustainable population (~ 40%; Gary Page, Lynne Stenzel pers. comm.). Based on the brood sample, productivity once broods hatched was at sustainable levels, with brood success near post predator management average ($\bar{x}$ = 74%), fledging success near post predator management levels (Table 10), and the number of fledglings per sampled brood above recovery goals (Table 9). The estimated number of fledglings produced was 250, lower than the previous four years (Table 11). Due to the relatively high number of male plovers detected during the residency period (15 Apr – 15 July, n ≈ 312), the overall number of fledglings per male was below recovery goals (Table 10). The data indicated that low nest success was the main cause of a decline in fledgling production, as the sample indicated that once broods hatched, they fared relatively well. If overall nest success was at the average (ca. 40%), the estimated number of fledglings would have exceeded the number of resident males and reproductive output would have been at recovery goals. The overall breeding coefficient (0.15 +/- 0.08) was lower than in 2020 (0.18 +/-0.05, Lauten *et al*., 2020). Productivity at Overlook, Tahkenitch, and Bandon SPMA was very poor, negatively impacting the overall breeding coefficient (Table 9). The data indicate that poor nest success, with many eggs laid but very few hatched and very few resulting fledglings from these important nesting sites, was the main cause of a decline in plover productivity compared to the previous two years (Lauten *et al*., 2019 and 2020).

Lauten *et al*. (2020) noted that there are annual fluctuations in productivity parameters between sites and years. In 2020, South Siltcoos, North and South Overlook, North Tahkenitch, South Beach CBNS, and New River HRA had productive seasons. In 2021, North and South Overlook and North Tahkenitch had very poor reproductive seasons, while North Tenmile had a very productive season after having a very poor season in 2020. Lauten *et al*. (2020) shows that Siltcoos to Bandon SPMA is responsible for nearly 90% of all the eggs laid, eggs hatched, and fledglings produced since the early 1990s. Management should continue to focus its efforts on enhancing and maintaining good productivity at these sites (Siltcoos, Overlook, North Tahkenitch, CBNS and Bandon SPMA) which will lead to sustainable plover populations within the project area while supplementing and assisting to sustain populations along the Northern California coast, the Northern Oregon coast, and Washington. Maintaining overall average nest success of 40%, fledging success of 40%, fledgling per male at approximately 1.00 (Gaines 2019), and a 0.20 breeding coefficient should result in a stable to growing plover population along the Pacific Northwest coast.

Productivity Before and After Lethal Predator Management

Data from Floras Lake and Sutton Beach are sparse. We did not include data from Floras Lake in the graphs of productivity analysis, and data from Sutton Beach are displayed solely for the purposes of 2020 comparisons.

The 2021 overall nest success (Table 5) was much lower than the ten-year (2012 – 2021) average of 40.0% +/- 12%, and lower than the mean observed and calculated success rates reported by Page *et al*. (2009) from multiple studies. Post-predator management fledging success rates have improved at all sites except at Tahkenitch, Tenmile and CBNS where they have remained relatively stable but above 40% (Figure 22). The post-predator management mean brood success rate for all sites (2004-2021; $\bar{x}$ = 73.7%+/-7.2) was higher than the pre-predator management brood success rate (1991-2001; $\bar{x}$ = 62.9%+/-8.5). The post-predator management number of fledglings per resident male has improved at all sites except Tenmile and CBNS where it has remained relatively stable at nearly 1.20 for Tenmile and nearly 1.50 for CBNS (Figure 23). The overall productivity has increased in the post-predator management time period resulting in a substantial increase in the number of hatched eggs and fledglings (Figure 24) and the overall population of plovers both within the project area and on the Oregon coast in general.

Discussion

As the plover population has increased, we have implemented sampling techniques that help balance our ability to sufficiently monitor the nesting sites while collecting adequate data to estimate reproductive parameters. From 2016 to 2020, we attempted to sample approximately 80% of the nests that successfully hatched (Lauten *et al*., 2016, 2017, 2018, 2019, and 2020). Lauten *et al*. (2020) details which nesting sites have contributed most to productivity and the increasing plover population and discusses focusing future management at these nesting sites because they will continue to contribute the most to a sustainable plover population. In 2021, due to the continued increase in both plover numbers and the locations where plovers are nesting, we reduced our brood sampling effort to approximately 50% of hatched nests with the goal of continuing to obtain adequate reproductive metrics while sufficiently monitoring the maximum amount of the nesting areas (Appendix C). We reduced monitoring efforts at Sutton Beach and Floras Lake and did not band any broods at these two beaches, however because of the low number of active broods at these sites, we were able to monitor several broods at each site. We also reduced monitoring and sampling efforts at South Tenmile because it is relatively remote, difficult to access, and has a limited number of plovers. We successfully banded 65% of hatched nests in 2021 (Table 9 and 12), 69 fewer broods than in 2020 (Lauten *et al*., 2020). Despite the lower number of banded broods, our estimates of brood success, fledging success and fledglings per sample brood were all similar to 2020 (Lauten *et al*., 2020) and brood success and fledging success were near the 10-year average, suggesting that the smaller sample yielded representative reproductive data.

The number of fledglings per male is considered an important recovery criterion, with the goal of maintaining 1.00 fledglings per male (USFWS 2007). Prior to 2016 we attempted to band all known hatched broods and the calculations for fledglings per male were based on how many known males were confirmed breeding. There was likely bias in the calculation because some males may have attempted to nest but were never confirmed on nest or with a brood, and therefore were not counted as a breeding male. Under-counting breeding males could lead to higher estimates of fledglings per male. Since 2016, as the population has continued to grow, we have estimated the number of breeding males per site because not all nests were being sampled and some males were never confirmed breeding. Males observed between 15 April to 15 July were considered resident males, i.e., a male may have attempted to nest at that site. Counting resident males based on presence alone likely overcounts the number of males that actually breed, and therefore biases the fledgling per male estimates downward.

We believe that the number of fledglings per resident male that we have been calculating since 2016 is not the best measure of reproductive output, and we believe that number of fledglings per brood is a better assessment of male productivity. The average number of fledglings per male for the six-year period of 2010 to 2015 was 1.37 +/- 0.30, while the average number of fledglings per resident male for the six-year period of 2016 to 2021, when we started sampling and changed the calculation methodology based on the number of resident males, was 0.84 +/- 0.20. Yet during the 2016 to 2021 period, the number of fledglings produced was well over 200 for every year except 2016 (Table 11), and the adult population increased each year except between 2016 and 2017 (Table 1). During this same period (2016-2021), the number of fledglings per sampled brood (Table 9) averaged 1.23 +/- 0.12, much higher than the number of fledglings per resident male. The growing population suggests that productivity estimates based on the number of fledglings per resident male is biased low because it includes males that do not breed.

We introduced the concept of breeding coefficient as a measure of plover productivity in 2017 (Lauten *et al*., 2017). The breeding coefficient is a measure of reproductive output based on effort. The number of fledglings per male is subject to bias based on how males are counted and can vary considerably because the ratio is based on a relatively small number of males; any change in the number has a large effect on the calculation. The breeding coefficient is based on how many eggs are laid, a number that is easier to count and is much higher than the number of fledglings, and therefore small variations in the count of eggs do not have a large impact on the calculation (Colwell *et al*., 2017). Thus, the breeding coefficient is more robust and stable assessment of reproductive output than fledglings per male. Sites that are very productive in any given year always have high breeding coefficients while sites that are not productive will have low breeding coefficients (Lauten *et al*., 2017, 2018, 2019, and 2020). The breeding coefficient also indicates which sites are source or sink populations and informs management where efforts could be made to either protect a source population or improve reproductive output at sink populations. As the Oregon population grows, the percent of the population that is closely monitored will decline, making identification of breeding males more difficult. Under these conditions, the breeding coefficient can provide a more reliable measure of reproductive output than fledglings per male. Maintaining high breeding coefficients, i.e., high reproductive output for the effort, will lead to sustainable or growing plover populations.

Sutton Beach and the Dunes NRA

Sutton beach has the lowest average reproductive parameters within the project area (Figures 21-23) due to raven activity and windy conditions. Both monitors and WS agents have limited available time to visit this site, and due to the low plover population at this site reproductive output will likely remain low. We expect plovers to continue to occupy this site in low numbers.

North Siltcoos had the most productive year since 2017 (Table 11) and the second most productive year since monitoring began at this site in 1994. Due to its relatively small size and high recreational activity, we expect this site to have limited numbers of breeding adults and fledglings. South Siltcoos continues to be productive, resulting in very good post predator management reproductive parameters for Siltcoos (Figures 21-23).

Lauten *et al*., (2020) discussed that plovers nesting from South Siltcoos to North Tahkenitch contributed substantially to annual and long-term population levels. In 2020 these sites produced 45% of all fledglings; in 2021 these sites produced only 22% of the fledglings (Table 11). The substantial decline was due to very poor nest success (Table 5) and relatively poor fledgling productivity caused by persistent predator pressure. Due to the low reproductive output at Overlook and Tahkenitch in 2021, the total number of fledglings produced was negatively impacted (Table 11). As noted in Lauten *et al*., (2020) these nesting sites are important to plover recovery in Oregon and reduction of predation pressure at these sites is essential for sustainable plover populations.

Limited surveys at South Tahkenitch and North Umpqua indicate that plovers continue to occupy available beach habitat. We expect plovers to continue to occupy this area and any available habitat created, but we are unable to consistently survey these areas.

Productivity at Tenmile in 2020 was very poor with low fledgling numbers (Table 11) and a poor breeding coefficient (Lauten *et al*., 2020). In 2021 we only sampled from the north side (Table 9), and productivity was very good (Table 9). The higher productivity was due to a reduction in predation pressure, resulting in more nests hatched and three times the number of fledglings produced (Table 11). We did not sample broods on South Tenmile, but it appeared productivity was muted there based on low nest success (Table 5). South Tenmile had more evidence of Northern Harrier activity (Table 8), which likely was the main cause of low productivity. Overall, Tenmile produced 30% of the total number of fledglings and 51% of the fledglings produced on the Dunes NRA (Siltcoos to Tenmile) (Table 11). The very good productivity in 2021 was a critical contribution to the overall reproductive output of both Forest Service lands and Oregon. Continued effective predator management at Tenmile is a critical management activity contributing to reproductive success. We continue to document human and dog violations of roped and signed nests in the South Umpqua area with some of the activity potentially being deliberate.

Lauten *et al*., (2020) documented the significant contribution of plovers nesting on the Dunes NRA to maintaining and growing plover populations. Data from 2020 and 2021 show how individual nesting areas can have large fluctuations in annual productivity, with Overlook and Tahkenitch having a very poor year in 2021 but being very productive in 2020, and Tenmile having low productivity in 2020 and much higher productivity in 2021. This offsetting productivity ensures that the plovers are having reasonably good overall success despite some individual sites having poor success. Effective predator management from Siltcoos to South Tenmile continues to be a critical management action resulting in successful plover productivity.

Coos Bay North Spit

WS observations early in the 2021 season indicated multiple Northern Harriers hunting and displaying over the nesting area at CBNS (USDA-APHIS-Wildlife Service 2021). Early season surveys found a majority of the plovers flocking together well north of the FAA towers on the beach, and north of South Spoil and HRAs, in a location that we have not documented flocking behavior in previous years. The first documented nest depredation by a harrier was on 6 April. Three harrier nests were located, two within the designated Snowy Plover nesting area, and one north of the nesting area. Continued observational data and nest data indicated harriers were targeting plovers; a pair of harriers was subsequently removed (USDA-APHIS-Wildlife Service 2021). Nest success improved and harrier activity was generally low for most of the remainder of the season, and plovers were much more successful on the nesting area than in 2020 (Lauten *et al*., 2020). Data from CBNS continues to show that harriers have a negative impact on plover productivity, and when removed from the area, plover productivity increases (Figures 17-20). Harriers are now recorded annually at all monitored plover nesting sites indicating that they are a regular predator of plovers.

Annual variability in plover production was also evident at CBNS. In 2020 South Beach produced the majority of fledglings due to harrier activity on the nesting area (Table 11). In 2021 the HRAs and South Spoil produced the majority of fledglings after the harriers were removed and predation declined substantially. CBNS continues to be the most productive nesting site north of central California (Lauten *et al*., 2020). Effective predator management at CBNS is essential to maintain high reproductive output at this critical site. CBNS and the Dunes NRA continue to be the most productive nesting sites on the Oregon coast, and are largely responsible for maintaining plover population in the entire recovery unit.

Lauten *et al*. (2020) discussed the loss of habitat on South Beach, CBNS due to westward encroachment of beachgrass and rising sea levels. We continue to note substantial loss of habitat in front of the foredune, reducing critical habitat, limiting nesting locations, and leaving nests more susceptible to human violations and disturbance. In 2021 we documented numerous vehicle violations, often east of carsonite signs or ropes, with tire tracks near active nests. Ropes along the entire beach are important to preventing most violations, however due to western beachgrass encroachment, ropes and signs are often at or in the high tide surf, leaving no room for recreational activity, and encouraging vehicle and human violations of the high dry sand. Some reduction of recreational violations could be achieved by removing vegetation in front of the stable, tall foredune and having a vegetation-free wave slope where plovers can safely nest, ropes can be safely installed, and recreational activity is allowed further west of nesting plovers, thus reducing recreational conflicts. Maintaining vegetation free corridors through the foredune creates paths for plover broods to access the beach, where food availability is higher and predation pressure is lower.

Bandon SPMA

Bandon SPMA has some of the most extensive natural habitat on the coast, and is one of the three nesting areas with the highest number of nesting plovers (Table 3). In 2021, brood success, fledging success and the number of fledglings per brood all improved compared to 2020 (Table 9, Lauten *et al*., 2020), however the breeding coefficient was very low in both 2020 and 2021, indicating that there is very poor productivity for the effort (Table 9). Bandon SPMA produced more eggs than any site but produced a very low number of fledglings for that effort (Table 11). On the Bandon Beach side, the beach continues to be eroded by the northward movement of the mouth of New River, and lack of any habitat management at this site for over five years has reduced the available nesting habitat to a very narrow strip in front of the foredune, and that area is littered with large woody debris, further reducing available habitat. Plovers however continue to nest at this site in relatively high density (Figure 12). The high nesting density in conjunction with limited available habitat resulted in gray fox targeting nesting plovers along the foredune. In addition, this site has relatively high recreational use with recreational activity occurring near ropes and signs resulting in disturbance of nesting and brooding plovers. Lack of habitat management also has pushed some plovers north of the restricted section of beach, and north of China Creek, into marginal habitat that is exposed to more recreational activity. Bandon Beach also has repeated dog violations, as well as bike violations, resulting in more disturbance to plovers. This area has been an important plover nesting beach and will continue to be occupied into the future. To improve reproductive output, this section of beach needs quality habitat restoration that would give the plovers good nesting options away from recreating public and windblown sand, and reduce the cover that predators like gray fox are using to hunt eggs, chicks, and adult plovers. Bandon Beach is a very important nesting beach due to the density of plovers present and the potential number of fledglings it can produce. Plovers will continue to struggle at Bandon Beach until this is resolved.

The New River spit continues to expand due to the northward movement of the mouth of the river. There is a large, open, dune and mostly grass-free sand spit for approximately a mile south of the mouth of the river, providing plovers with prime natural nesting habitat. In 2020, this area was littered with much woody debris and wrack material. In 2021, winter overwashing of the spit removed all woody debris, leaving an open spit with little cover and little tidal debris to camouflage nests. However, plovers nesting in this area are subject to egg burial due to windblown sand. Further south, extensive dunes have developed as the river moves north and beachgrass is established, resulting in loss of plover nesting habitat. No habitat restoration has been completed here in over five years. Despite the dune formation, the New River spit still has extensive available habitat and is occupied by numerous plovers. Unfortunately, in 2021 productivity at this site was extremely low due to poor nest success (Table 5) caused by a Western Gull. Identifying the gull was difficult and time consuming and removing the specific gull took nearly eight weeks. By the time the gull was removed, the nesting season was mostly completed. Nest success improved and the few nests that hatched fared reasonably well, but the breeding coefficient was extremely low indicating very poor productivity for the number of plovers and nests at this site (Table 9). We did not detect the persistent presence of any other predator at New River spit in 2021. In 2020, Lauten *et al*. (2020) documented Great Horned Owl impacts at New River spit; we did not find much evidence of owls in 2021. We did have some raven activity on the spit, but it was limited and ravens caused minimal damage. New River spit, and all of Bandon SPMA is an important nesting area based on the number of plovers present (Table 3) and the number of nest attempts (Table 4). Bandon SPMA has lower hatch rates, fledge rates, and fledglings per male than the other sites with large number of plovers (Figures 21-23). Improvements in plover productivity at this site would be very beneficial for all of Recovery Unit 1 and parts of Recovery Unit 2. To improve productivity at this site, habitat maintenance and restoration are needed at both Bandon Beach and on the southern section of New River spit, and effective predator management is essential. Bandon SPMA is the only site where gulls have repeatedly been problematic, and typically it has been one individual causing the majority of damage. WS and ORBIC staff intend to intensely monitor this area in the future for problematic gulls with the goal of quick removal of offending individuals. Improved nest success at Bandon SPMA would likely result in higher numbers of chicks and potential fledglings as once chicks are hatched, broods tend to fare reasonably well. We continue to recommend regular patrolling of Bandon SPMA to manage recreation activities, as this site has regular recreational activity in the China Creek area.

New River

As noted in Lauten *et al*. (2020), habitat along private land at New River has degraded due to beachgrass and dune growth. Small numbers of plovers continue to utilize this section of beach (Table 3) and produced low numbers of fledglings (Table 11). We expect small numbers of plovers to continue to occupy this section of beach, but due to ownership and local landowner use, no management actions except some limited predator management are feasible.

There was increase in plover activity at New River HRA in 2021 (Table 3). Nest numbers also increased (Table 4), partly due to increased plover usage but also due renesting attempts after nest failure. Prior to 2020, most plover activity on the New River HRA was concentrated at the south end from Hammond breach to Clay Island breach (Lauten *et al*., 2018 and 2019). In 2020 (Lauten *et al*., 2020), plovers increased their use of the north end of the HRA south to Croft Lake breach. In 2021 plovers were active throughout the entire breeding season from just north of the HRA south to Croft Lake breach, and then from Croft Lake breach south to just south of New Lake breach. We also documented some nesting activity on Clay Island breach. There is much available habitat at New River HRA, and it is encouraging to document plovers utilizing a majority of the HRA. New River HRA typically contributes low numbers of fledglings (Table 11). Proximity to local sheep and cattle ranches has resulted in relatively high levels of raven and red fox activity which negatively affects plover productivity. New River HRA likely has the lowest density of plovers in the project area compared to available nesting habitat. Maintaining habitat at the New River HRA benefits adjacent nesting areas at Bandon SPMA by reducing vegetation cover that red fox and other mammalian predators inhabit, and also provides alternative nesting locations for plovers nesting within the Bandon to Floras Lake system. Effective predator management in this area has reduced the overall number of red fox, and continued predator management could lead to increased plover numbers and productivity.

Floras Lake

Floras Lake harbors small numbers of plovers (Table 3), nests (Table 4), and typically produces small numbers of fledglings (Table 11). Predator activity is persistent at this site due to the proximity of sheep and cattle ranches, with ravens, skunks, and red fox being particularly problematic. Recreational activity is also problematic at this site, with repeated dog and human violations of restricted areas. Due to the small number of broods at this site, we did not band any broods but were able to successfully track the two broods that hatched (Table 9). We expect plovers to continue to occupy this site in low densities. Habitat at Floras Lake is naturally maintained by ocean wave and overwash activity, and continued management of the site will likely result in the production of small numbers of fledglings.

Conclusion

In 2021 we implemented a reduced sampling plan and sufficiently measured plover productivity. Overall plover numbers were at their highest (Table 1), and while the total number of fledglings was lower than the previous four years (Table 11), productivity was reasonably good (Table 9). Successful production of plovers within the project area is critical to populations from Washington to Mendocino Co., CA, and effective predator management is important to the success of the plovers (Gaines *et al*. 2020). In Lincoln Co., OR at well-monitored sites with no predator management, of 48 plover nests found in 2021, one hatched, producing one chick that did not survive to fledging. Other nesting data from northern Oregon sites with no predator management suggests very low nest success and limited plover productivity. Observations of plovers in Lincoln Co. reveal that almost all originate from within the project area. Observations from WA, the northern Oregon coast, and RU2 indicate that plovers from the project area are contributing to maintain all these populations. Effective predator management within the project area has significant impacts on the entire northwestern Pacific coast, and management efforts should focus on prioritizing plover productivity at the main nesting sites between Siltcoos and New River.

Immigrant Plovers

Thirty-three adult plovers banded in California were observed in Oregon in 2021. Twenty-one were females and 12 were males. Nineteen females and 12 males were resident plovers and two females were present outside of the breeding season and were likely either wintering or visiting plovers.

Of the 33 plovers banded in California, six females and two males originally hatched in Oregon and were subsequently rebanded at coastal nest sites in California. All other immigrant plovers were originally banded in California.

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Table 1. Minimum window survey counts and the minimum number of Snowy Plover present from Sutton Beach to Floras Lake, Oregon Coast, 2010-2021.

YEAR	WINDOW SURVEY	# SNPL PRESENT
2010	158	232
2011	168	247
2012	206	293
2013	215	304
2014	228	338
2015	277	458
2016	375	529
2017	282	468
2018	311	502
2019	356	517
2020	403	563
2021	481	613

Table 2. Number of banded Snowy Plover fledglings, number of previous year fledglings returning, return rate, along the Oregon coast, 2011 - 2021.

Year	**# of banded fledglings from previous year**	**# of HY birds from previous year sighted on OR coast**	**Return Rate (#HY/#Fled)**
2010	105	54	51.4
2011	84	53	63.1
2012	161	92	57.1
2013	162	91	58.7
2014	98	54	56.3
2015	260	146	56.2
2016	305	135	44.4
2017	171	69	40.4
2018	245	120	48.9
2019	270	109	40.3
2020	274	124	45.2
2021	231	93	40.3
		AVERAGE =	50.1
		STDEV =	8.44

Table 3. Plover activity based on the number of adult plovers at each nesting area on the Oregon Coast, 2021. Plovers move between nesting areas throughout the breeding season, therefore this is not a tally of the total number of plovers present.

	Females				Males					
	Banded		Unbanded		Banded		Unbanded		Total	
Site	# banded	# residents	# unbanded	# residents	# banded	# residents	# unbanded	# residents	# plovers	# residents
Sutton	5	5	1	1	9	9	1	1	16	16
Siltcoos	32	26	7	7	29	19	9	9	77	61
Overlook	64	50	7	7	65	52	3	3	139	112
Tahkenitch	48	41	4	4	44	43	4	4	100	92
Tenmile	31	28	14	14	37	36	15	15	97	93
CBNS	57	53	10	10	65	63	12	12	144	138
Bandon SPMA	57	44	8	8	57	51	6	6	128	109
New River private	7	7	0	0	9	6	0	0	16	13
New River HRA	11	10	4	4	13	12	3	3	31	29
Floras Lake	3	3	0	0	5	5	1	1	9	9

Table 4. Number of nests for selected sites on the Oregon Coast 2011 – 2021 cells tally nests only and not broods from undiscovered nests. The number of broods from undiscovered nests is totaled for each year only.

Site Name	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
SU	0	0	1	2	8	19	21	20	15	20	11
SI:											
North	13	10	13	6	8	15	25	15	12	13	21
South	21	22	30	18	23	42	31	24	29	24	29
OV:											
North	29	28	33	35	46	48	61	24	38	52	75
South	28	31	28	23	42	56	47	34	35	50	80
TA											
North	23	36	52	32	61	74	56	47	49	62	75
South			6	4	2	0	2	1	8	8	6
TM:											
North	15	17	19	26	29	34	40	66	52	103	90
South	35	29	17	21	32	59	24	33	26	33	25
CBNS:											
SB	16	7	36	20	41	48	33	32	29	52	26
SS	15	15	12	13	20	38	27	29	27	20	19
HRAs	26	39	58	43	66	97	74	67	78	61	80
BSPMA											
BB	28	48	44	28	40	57	32	36	51	39	62
NR spit	9	12	20	54	48	73	49	43	70	92	83
NR HRA	29	17	9	15	27	14	11	10	16	12	24
NR other	2	1	3	4	8	18	11	5	7	1	3
FL	0	2	0	2	0	1	3	4	9	8	3
Tot nst	**289**	**314**	**381**	**346**	**501**	**693**	**547**	**490**	**551**	**650**	**712**
Tot brd[a]	**4**	**11**	**8**	**12**	**32**	**19**	**9**	**15**	**25**	**13**	**22**

[a] – broods from undiscovered nests only; these broods are not tallied in the total number of nests

SU – Sutton, SI – Siltcoos, OV – Overlook, TA – Tahkenitch, TM – Tenmile, CBNS – Coos Bay North Spit (SB - South Beach, SS – South Spoil, BSPMA – Bandon Snowy Plover Management Area (BB - Bandon Beach, NR spit - New River spit), NR HRA – New River HRA, NR other - private and other owned lands, FL – Floras Lake

Table 5. Apparent nest success of Snowy Plovers on the Oregon Coast, 2021.

Site	Total #	Hatch	Fail	Unknown	App Nest Success
Sutton	11	3	7	1	27%
Siltcoos					
North	21	11	10		52%
South	29	14	15		48%
Combined	50	25	25		50%
Overlook					
North	75	9	63	3	12%
South	80	11	67	2	14%
Combined	155	20	130	5	13%
Tahkenitch					
North	75	17	56	2	23%
South	6	0	6	0	0%
Combined	81	17	62	2	21%
Tenmile					
North	90	32	58		36%
South	25	6	14	5	24%
Combined	115	38	70	5	33%
CBNS					
South Beach	26	11	15	0	42%
South Spoil	19	8	9	2	42%
HRAs	80	45	35	0	56%
Combined	125	64	59	2	51%
Bandon SPMA	145	18	127	0	12%
New River					
HRA	24	8	16		33%
Other Lands	3	0	3		0%
Floras Lake	3	2	1		67%
Totals	712	195	502	15	27%

Forest Service total = 103/412=25% (DNRA=100/401=25%)

Table 6. Apparent nest success of Snowy Plover nests on the Oregon coast, 2012 - 2021 with ten year average and 1990 - 2021 overall average.

2012	45
2013	24
2014	60
2015	48
2016	25
2017	42
2018	49
2019	41
2020	40
2021	27
Average '12-'21	40.0
Standard deviation	11.6
Average '90-'21	45.6
Standard deviation	12.7

Table 7. Snowy Plover nests reported from outside the intensive monitoring area in 2021.

Site Name	County	Nests found	Hatched	Failed	Unknown nest fate
Clatsop Spit	Clatsop	18	3	3	12
Nehalem Spit	Tillamook	19	1	7	11
Bayocean Spit	Tillamook	Not monitored			
Netarts Spit	Tillamook	0	0	0	0
Sitka Sedge	Tillamook	5	0	5	0
Sand Lake	Tillamook	18	1	0	17
Agate Beach	Lincoln	4	0	4	0
Bayshore	Lincoln	7	0	7	0
Beachside SP	Lincoln	1	0	0	1
Collins Creek	Lincoln	2	0	2	0
Driftwood SP	Lincoln	1	0	1	0
Fox Creek	Lincoln	9	0	9	0
Sandpiper Village	Lincoln	13	0	13	0
South Beach SP	Lincoln	2	0	2	0
Sunset Street	Lincoln	1	1	0	0
Yaquina Bay SP	Lincoln	8	0	8	0
Total		108	6	61	41

Table 8. Causes of Snowy Plover nest failure at survey sites along the Oregon coast, 2021.

Site Name	Tot Nsts	# Fail	Depredations					Other					
			Corvid	Unk	Mammal	Harrier	Avian	Wind	Over-wash	Abandon	One Egg Nest	Infer	Unk cause
Sutton	11	7		4						1			2
Siltcoos:													
North	21	10	1	6			1			1			1
South	29	15		3		2	7			1	1		1
Overlook													
North	75	63	8	9	12 [a]	6	13			1	2		12
South	80	67	8	20	7 [b]	7	14		1	3	1		6
Tahkenitch													
North	75	56	24	13	6 [c]	2	7			1			3
South	6	6	1	3	1 [d]								1
Tenmile:													
North	90	58	2	15	13 [e]	1	9		2	7	2		7
South	25	14		2	1 [f]	4	6			1			
Coos Bay North Spit:													
South Beach	26	15	2	2				3		1			7
South Spoil	19	9	3	4							2		
HRAs	80	35	2	16		10				1	5	1	
Bandon SPMA	145	127	2	44	7 [g]		16 [h]	7		5	2	1	43
New River													
HRA	24	16	4	10	2 [i]								
Other lands	3	3		2								1	
Floras Lake	3	1		1									
TOTALS	712	502	57	154	49	32	73	10	3	23	15	3	83

[a] – 11 coyote depredations, 1 unknown mammal
[b] – 7 coyote depredations
[c] – 6 coyote depredations
[d] – 1 coyote depredation
[e] – 13 coyote depredations
[f] – 1 unknown mammal depredation
[g] – 5 gray fox depredations, 1 raccoon depredation, 1 skunk depredation
[h] – 14 gull depredations, 2 unknown avian depredations
[i] – 2 red fox depredations

Table 9. Number of broods sampled (number successful in parenthesis), brood success, and fledging success based on sample from Sutton Beach to Floras Lake, Oregon coast, 2021.

Site Name	# of broods in sample	% brood success	# of eggs hatched in sample	# of fledglings from sample	% fledging success	fledglings per sampled brood	breeding coefficient
Sutton Beach	3 (1)	33%	9	2	22%	0.67	3/30=0.10
Siltcoos:							
North Siltcoos	7 (6)	86%	20	10	50%	1.43	13/61=0.21
South Siltcoos	12 (8)	67%	31	13	42%	1.08	18/83=0.22
Overlook							
North Overlook	8 (5)	63%	18	7	39%	0.88	10/204=0.05
South Overlook	7 (4)	57%	20	8	40%	1.14	12/214=0.06
Tahkenitch							
North Tahkenitch	10 (7)	70%	28	8	29%	0.80	14/198=0.07
South Tahkenitch	NS						
Tenmile:							
North Tenmile	29 (26)	90%	78	43	55%	1.48	61/264=0.23
South Tenmile	NS						
Coos Bay N. Spit							
South Beach	7 (7)	100%	20	12	60%	1.71	13/67=0.19
South Spoil/HRA	29 (21)	72%	76	29	38%	1.00	64/262=0.24
Bandon SPMA	18 (13)	72%	46	19	41%	1.06	21/372=0.06
New River							
HRA	8 (7)	88%	19	9	47%	1.13	11/72=0.15
Other lands	NS						
Floras Lake	2 (2)	100%	5	2	40%	1.00	2/8=0.25
Total	**140**	**75%**	**370**	**162**	**44%**	**1.16**	

Table 10. Fledging success and mean number of fledglings/male (+/- standard deviation) on the Oregon Coast, 2004 – 2021.

Year	% Fledging Success	Mean # Fled/Male
2004	55	1.73
2005	41	1.28
2006	48	1.56
2007	54	1.60
2008	47	1.13
2009	50	1.33
2010	35	0.97
2011	47	1.61
2012	44	1.41
2013	39	1.04
2014	48	1.68
2015	49	1.51
2016	43	0.60
2017	50	0.90
2018	49	1.03
2019	54	1.07
2020	42	0.79
2021	44	0.62
’04-’21mean	46.6 +/- 5.3	1.22 +/- 0.36

Table 11. Total number of young fledged from select sites on the Oregon Coast 2010-2021, includes fledglings from broods from undiscovered nests.

Site Name	10	11	12	13	14	15	16	17	18	19	20[a]	21[a]
SU					1	3	2	2	8	8	8	3
SI:												
North	4	4	1	2	0	4	3	17	6	0	5	13
South	4	8	16	4	9	25	20	16	18	11	19	18
OV:												
North	12	27	22	3	18	26	33	17	15	40	36	10
South	7	23	27	0	25	39	16	30	25	45	39	12
TA:												
North	3	20	26	9	25	49	28	28	19	40	42	14
South				3	0	0		0	7	9	1	0
TM:												
North	3	1	5	15	35	26	14	41	46	31	21	61
South	13	5	5	8	27	21	27	24	20	10	8	10
CBNS:												
SS	2	6	10	2	14	13	9	10	20	8	8	9
SB	13	22	16	18	28	24	12	38	20	32	39	13
HRAs	5	28	34	3	49	46	12	10	49	18	26	51
CBNS						51		9	12	21		
BSPMA												
BB	6	16	11	8	12	12	8	28	21	18	9	15
NR spit	0	5	1	14	22	19	6	9	21	26	22	6
NR HRA	12	7	4	12	3	10	4	3	3	12	16	11
NR other	0	0	0	3	6	2	5	4	0	6	0	2
FL	0	0	2		2	0	1	4	6	9	0	2
Total	**84**	**172**	**180**	**104**	**276**	**370**	**200**	**290**	**316**	**344**	**299**	**250**

[a] – numbers are estimated number of fledglings based on number of broods and # of fledglings per sampled brood

SU – Sutton, SI – Siltcoos, OV – Overlook, TA – Tahkenitch, TM – Tenmile, CBNS – Coos Bay North Spit (SB - South Beach, SS – South Spoil, BSPMA – Bandon Snowy Plover Management Area (BB - Bandon Beach, NR spit - New River spit), NR HRA – New River HRA, NR other - private and other owned lands, FL – Floras Lake

Table 12. Number of resident males, estimated number of fledglings, and number of fledglings per male on the Oregon Coast, 2021. Plovers move between nesting areas throughout the summer, therefore the number of resident males is not a tally of the total number of plovers present.

Site Name	**# of resident males**	**estimated # of fledglings**	**estimated # of fledglings/male**
Sutton Beach	10	3	0.30
Siltcoos Spits	28	31	1.10
Dunes Overlook	55	22	0.40
Tahkenitch Creek	47	14	0.30
Tenmile Creek	51	71	1.39
Coos Bay North Spit	75	73	0.97
Bandon SPMA	57	21	0.37
New River			
HRA	15	11	0.73
Other lands	6	2	0.33
Floras Lake	6	2	0.33
Overall			0.62 +/-0.40

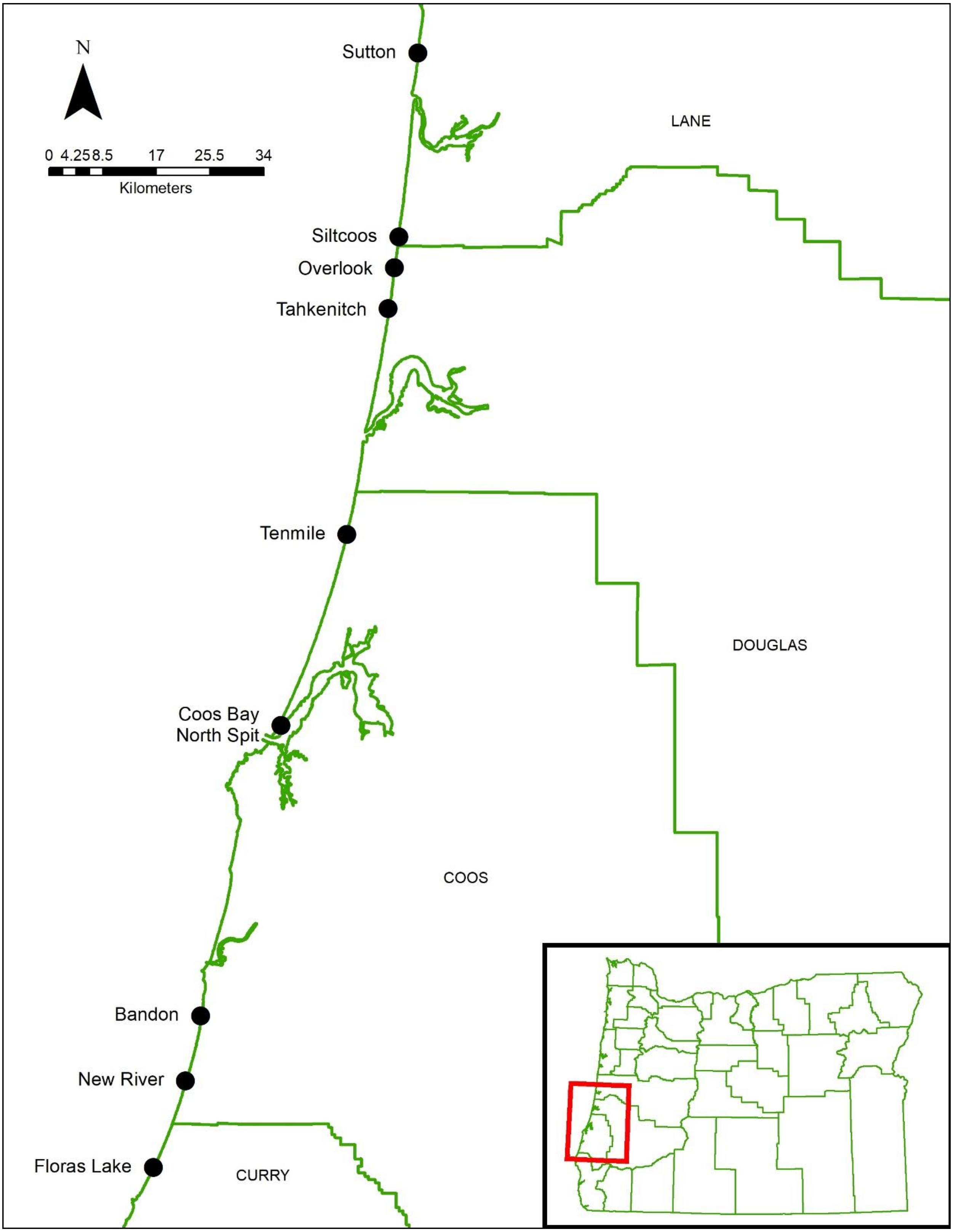

Figure 1. Snowy Plover monitoring locations along the Oregon Coast, 2021.

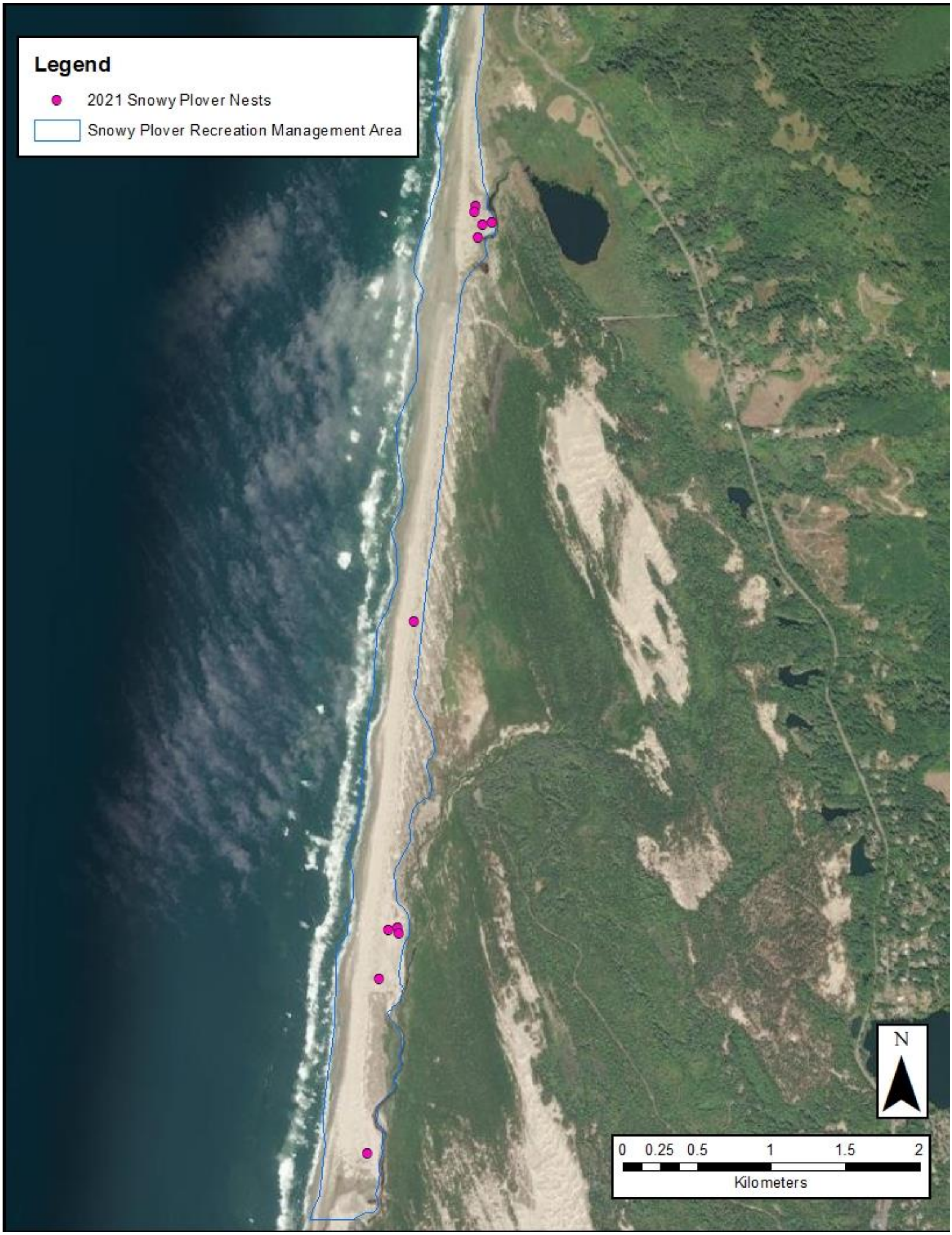

Figure 2. Snowy Plover nest locations at Sutton/Baker Beach, Oregon, 2021.

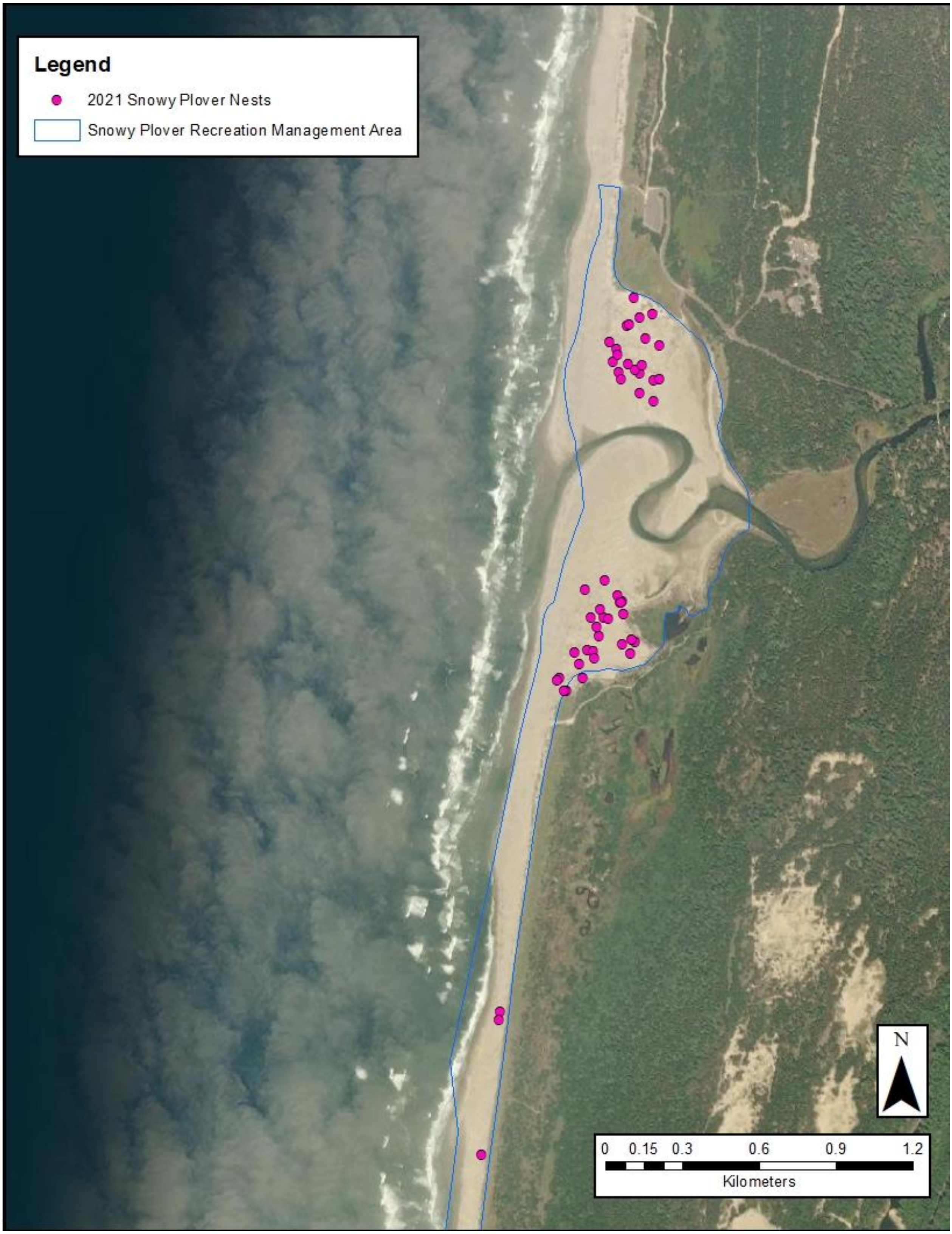

Figure 3. Snowy Plover nest locations at Siltcoos Estuary, Oregon, 2021.

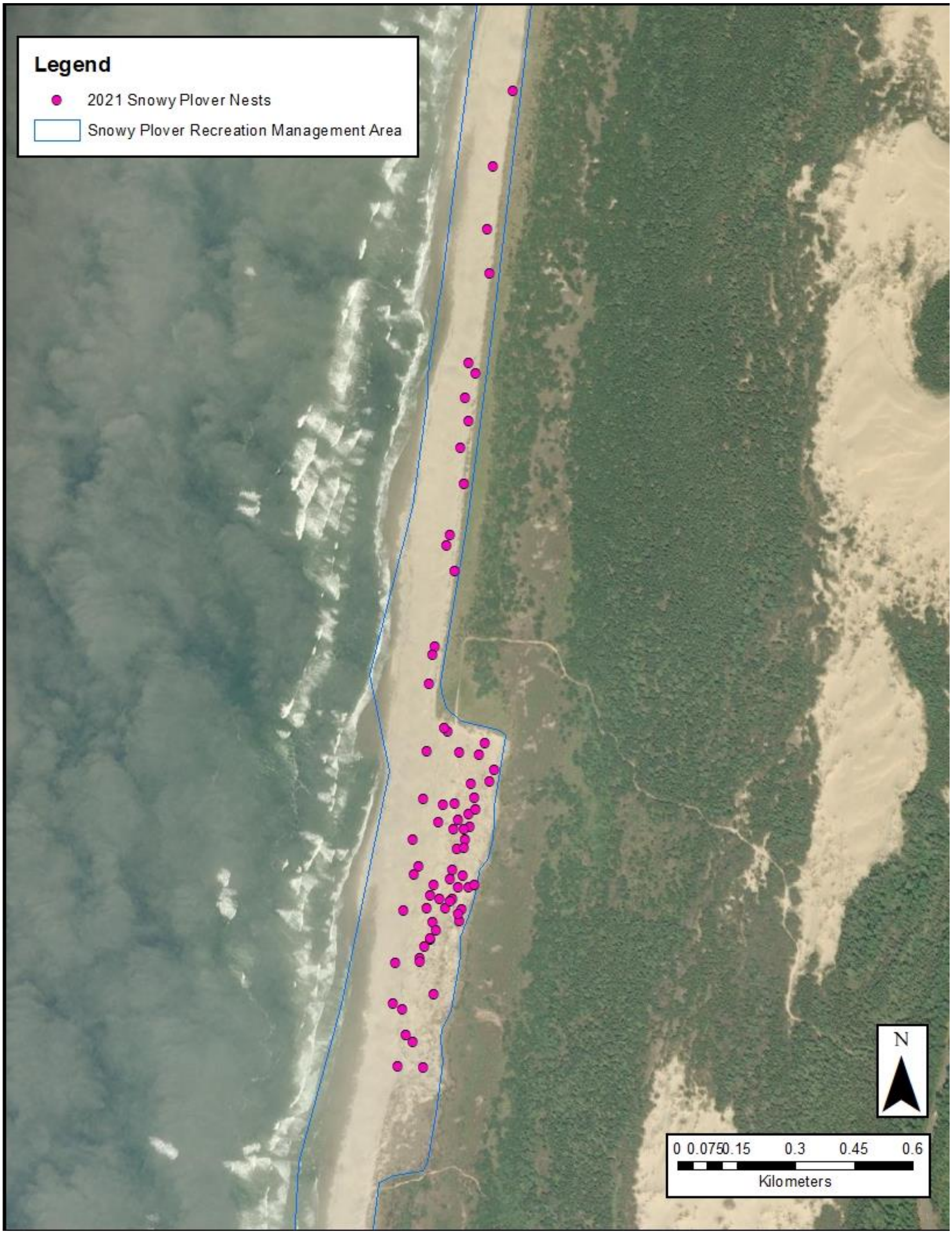

Figure 4. Snowy Plover nest locations at Dunes North Overlook, Oregon, 2021.

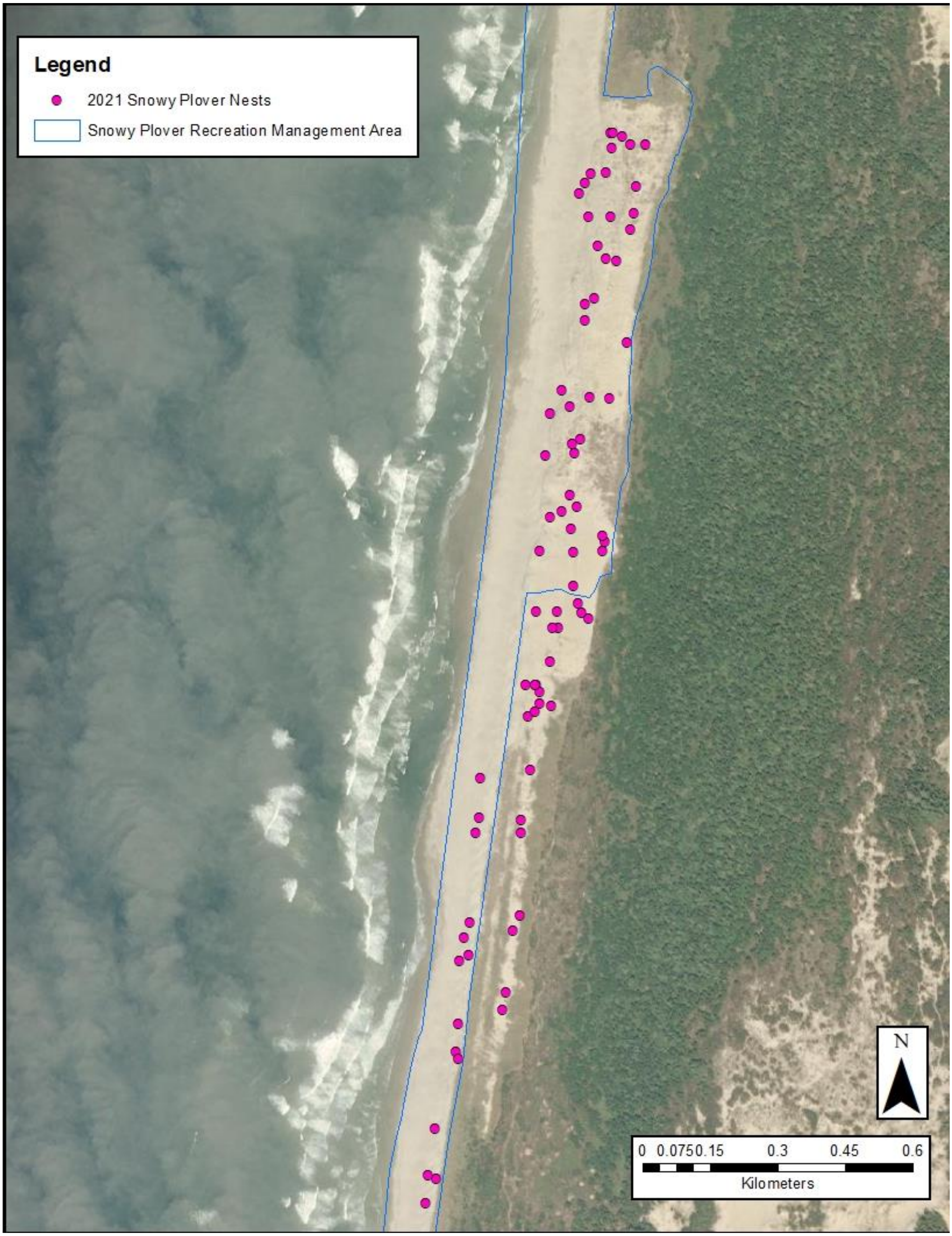

Figure 5. Snowy Plover nest locations at Dunes South Overlook, Oregon, 2021.

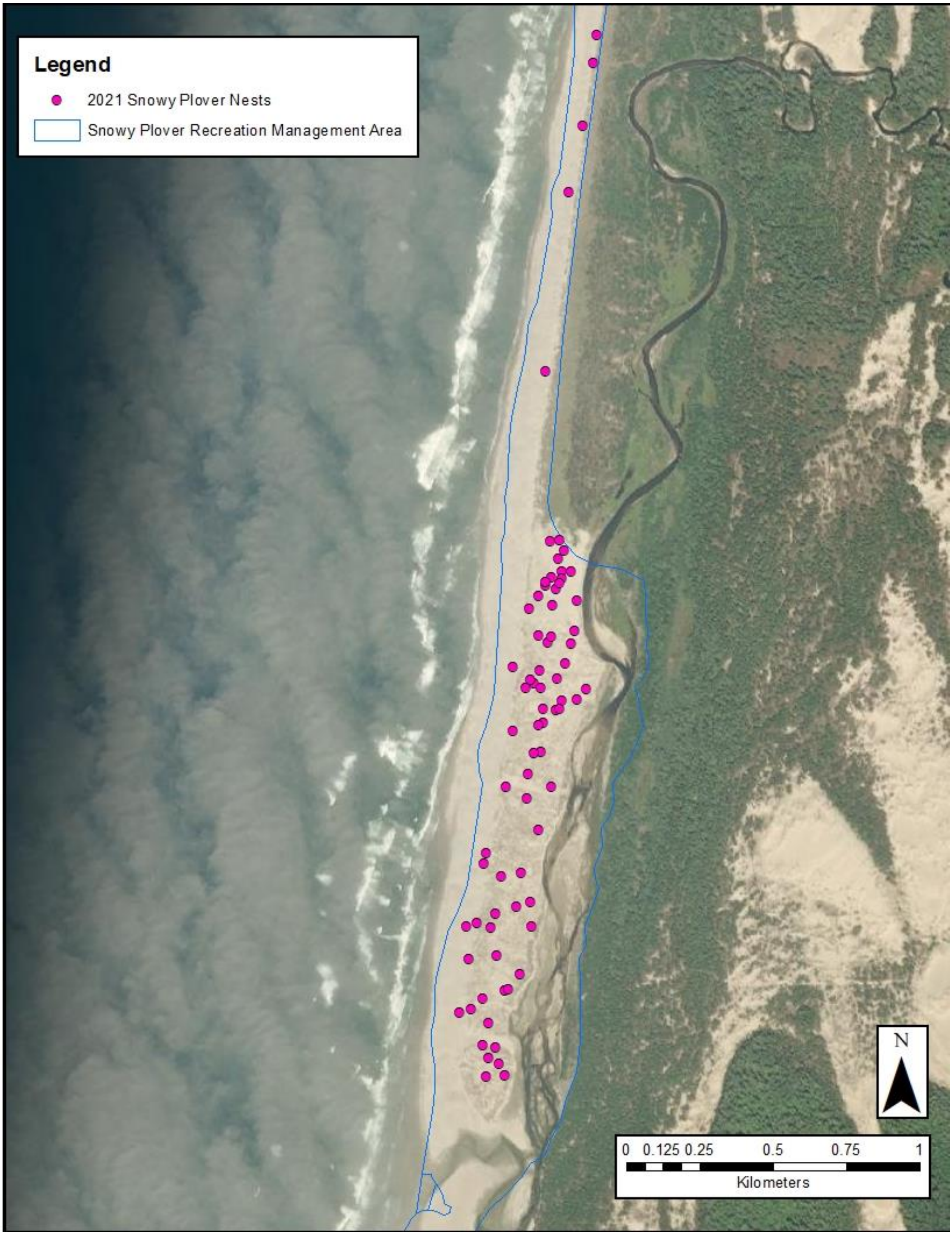

Figure 6. Snowy Plover nest locations on north side of Tahkenitch Creek, Oregon, 2021.

Figure 7. Snowy Plover nests on south side of Tahkenitch Creek, Oregon, 2021.

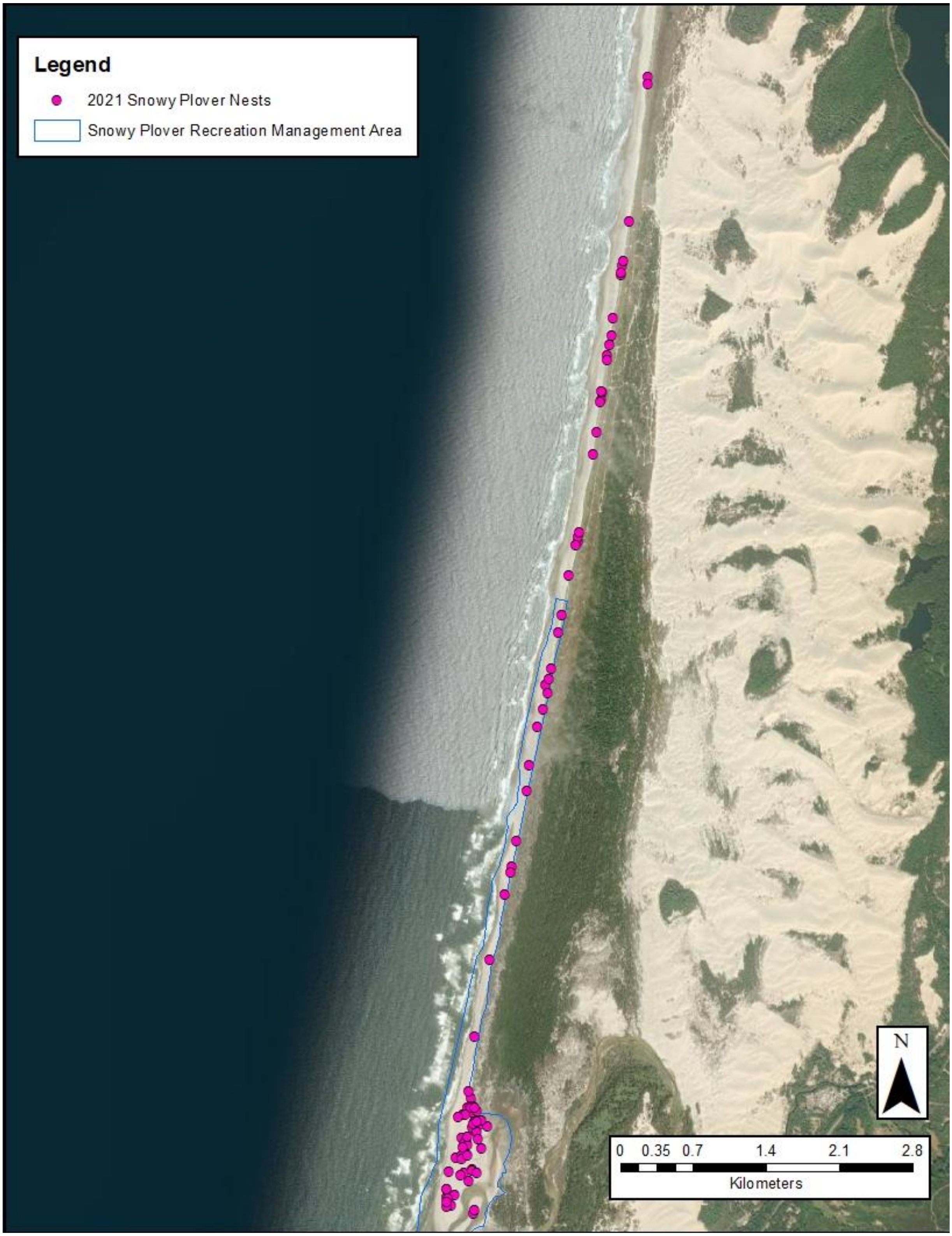

Figure 8. Snowy Plover nests on north side of Tenmile Creek, Oregon, 2021.

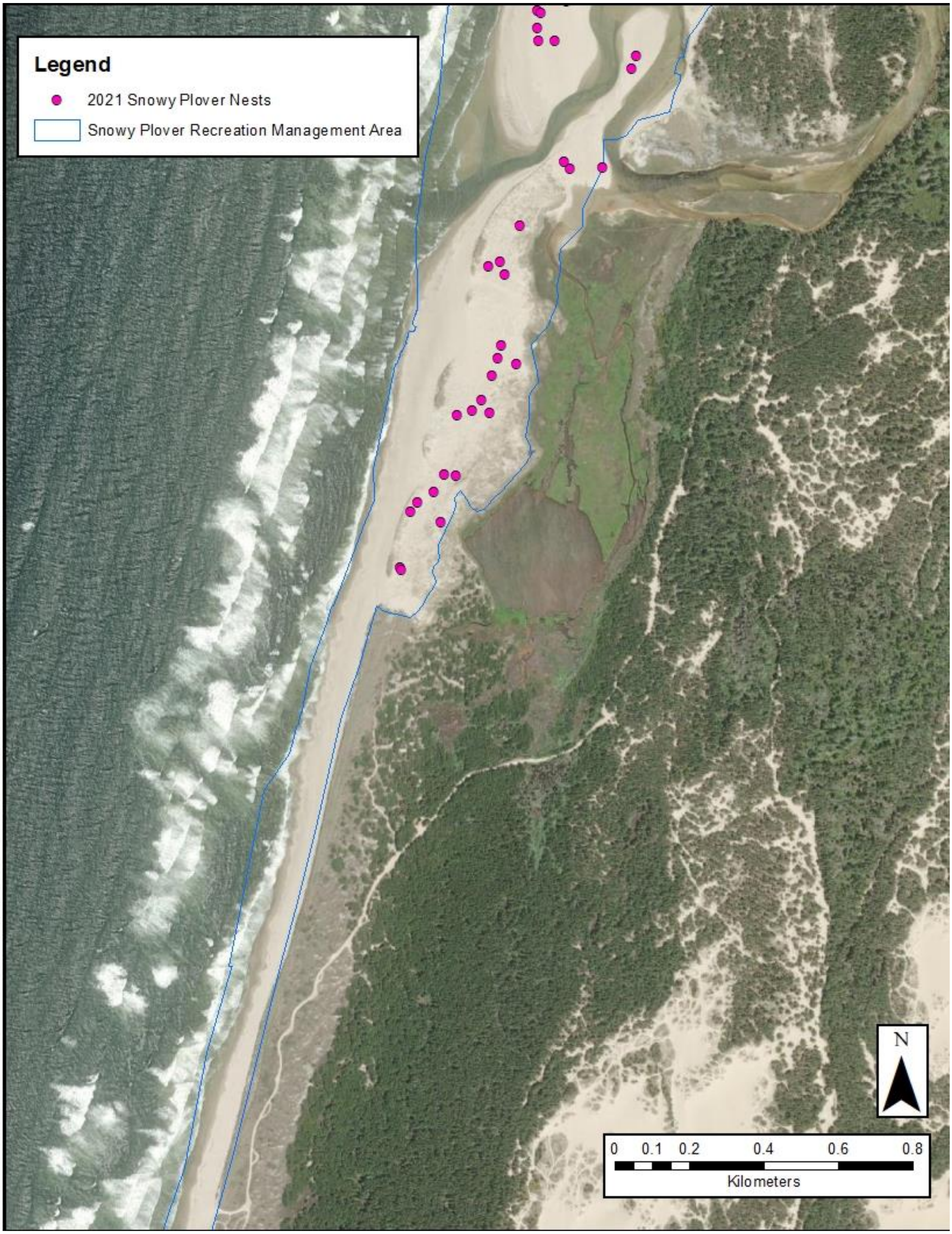

Figure 9. Snowy Plover nests south of Tenmile Creek, Oregon, 2021. Note that nests shown on north side of creek mouth are duplicates of those shown in Figure 8.

Figure 10. Snowy Plover nests on north end of Coos Bay North Spit, Oregon, 2021.

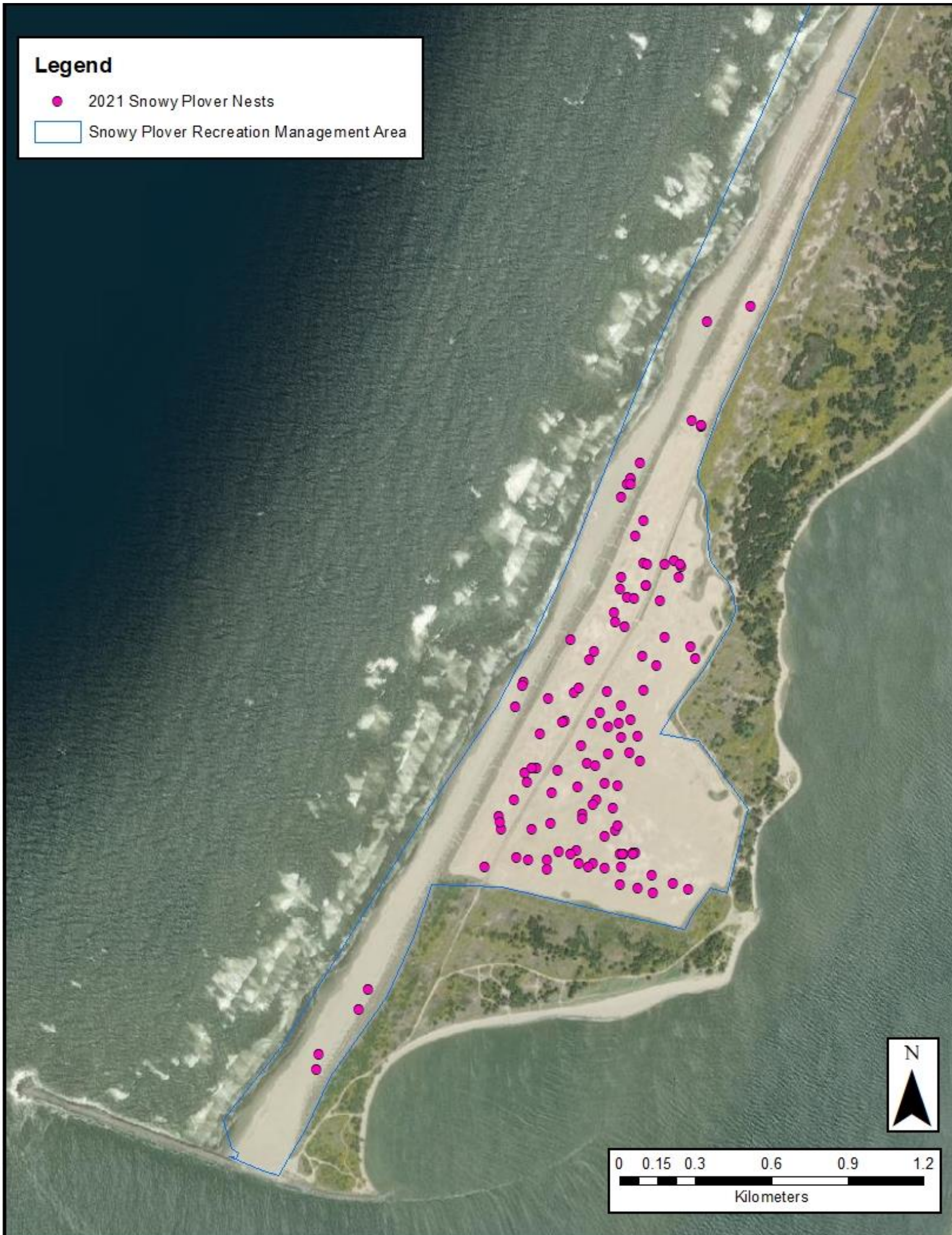

Figure 11. Snowy Plover nests at Coos Bay North Spit, Oregon, 2021.

Figure 12. Snowy Plover nests at Bandon SPMA, north of the mouth of New River, Oregon, 2021.

Figure 13. Snowy Plover nests at Bandon SPMA, south of the mouth of New River, Oregon, 2021.

Figure 14. Snowy Plover nest locations on New River Habitat Restoration Area, Oregon, 2021.

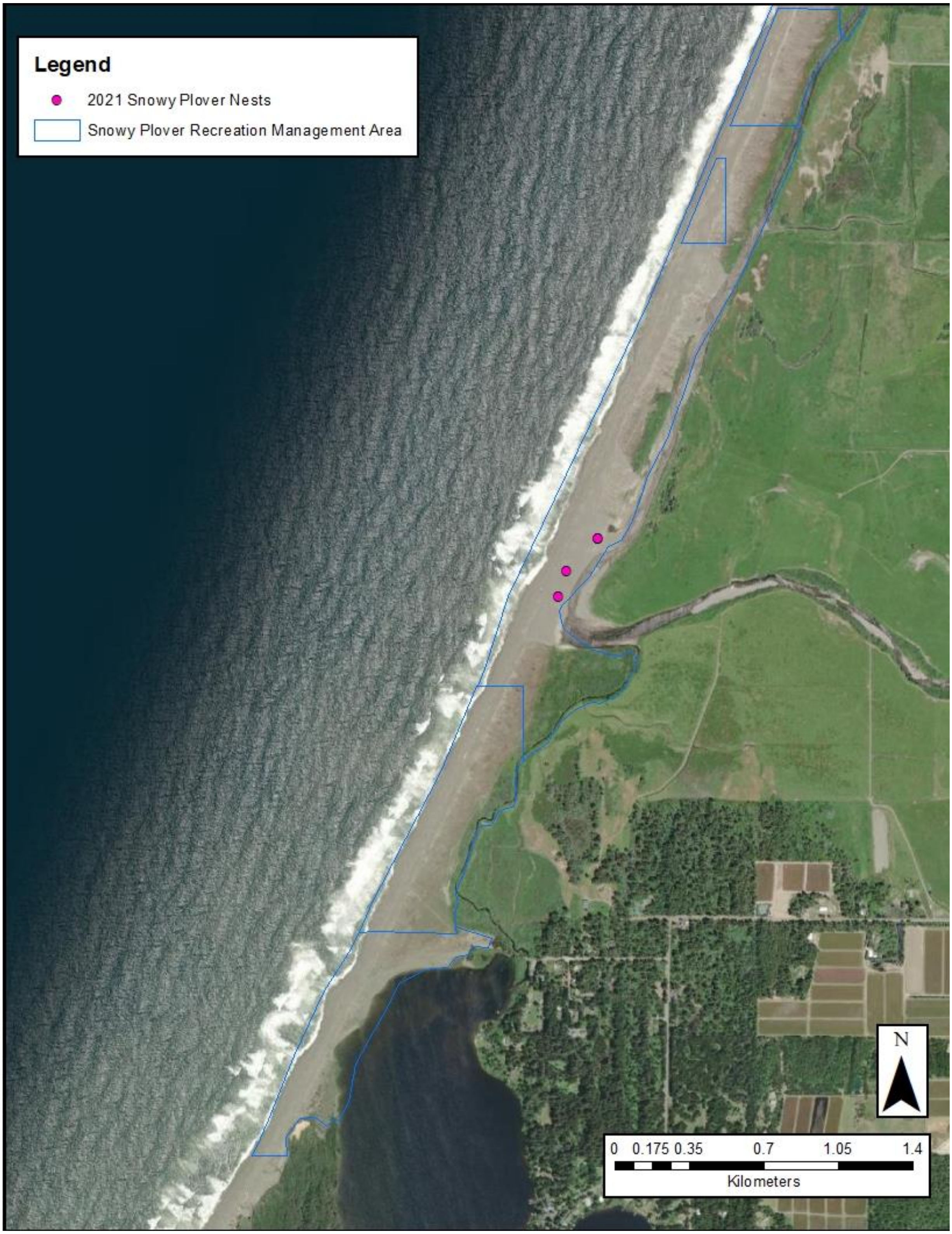

Figure 15. Snowy Plover nest locations at Floras Lake, Oregon, 2020
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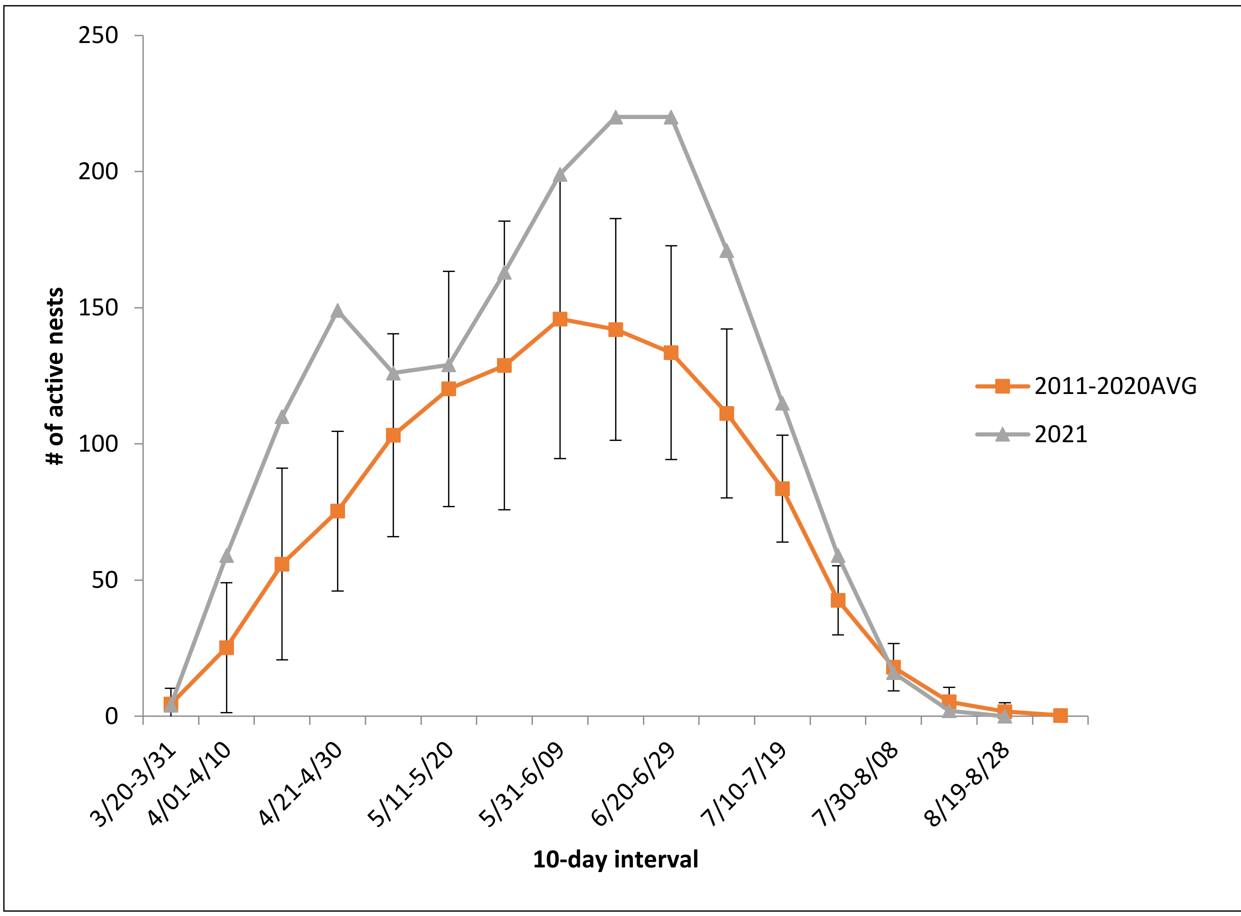

Figure 16. Number of active Snowy Plover nests within 10-day intervals on the Oregon coast, 2021. Dashed lines represent +/- standard deviation.

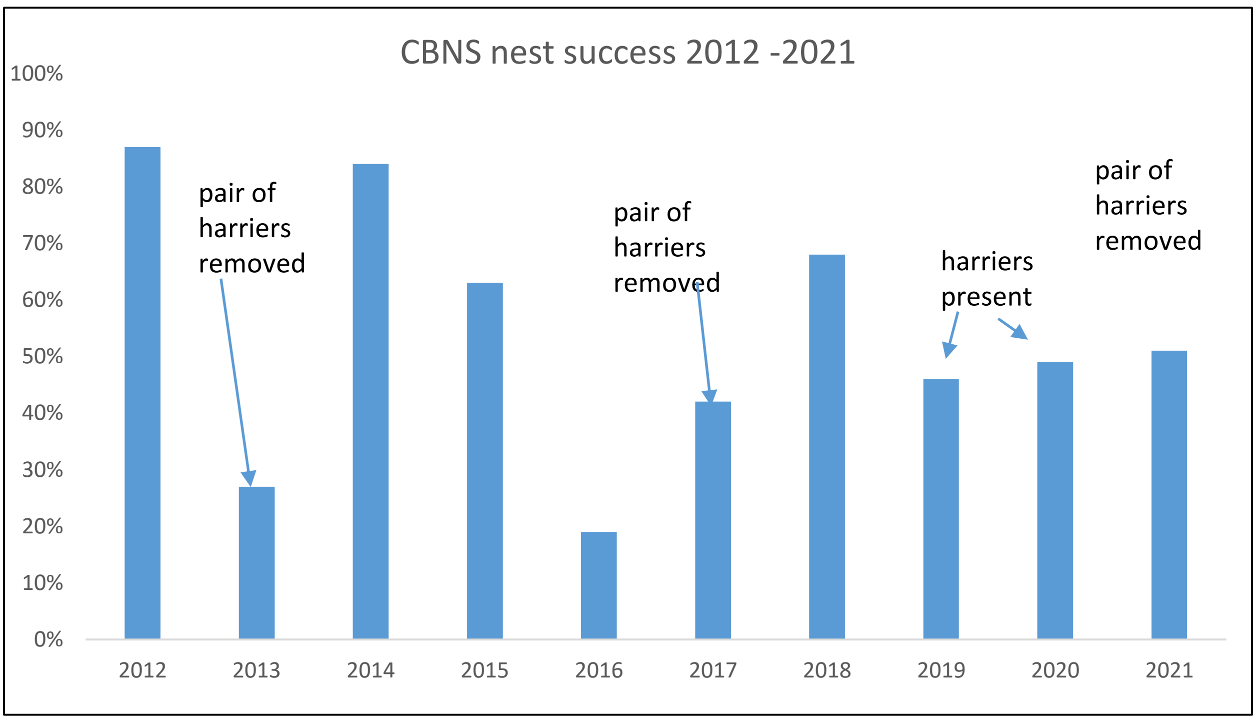

Figure 17. Nest success at CBNS 2012 -2021 A pair of Northern Harriers were removed after being identified as significant nest predator in 2013, 2017, and 2021. Note how nest success substantially increases in years after harriers were removed, indicating that harrier removal had a positive increase on plover nest success.

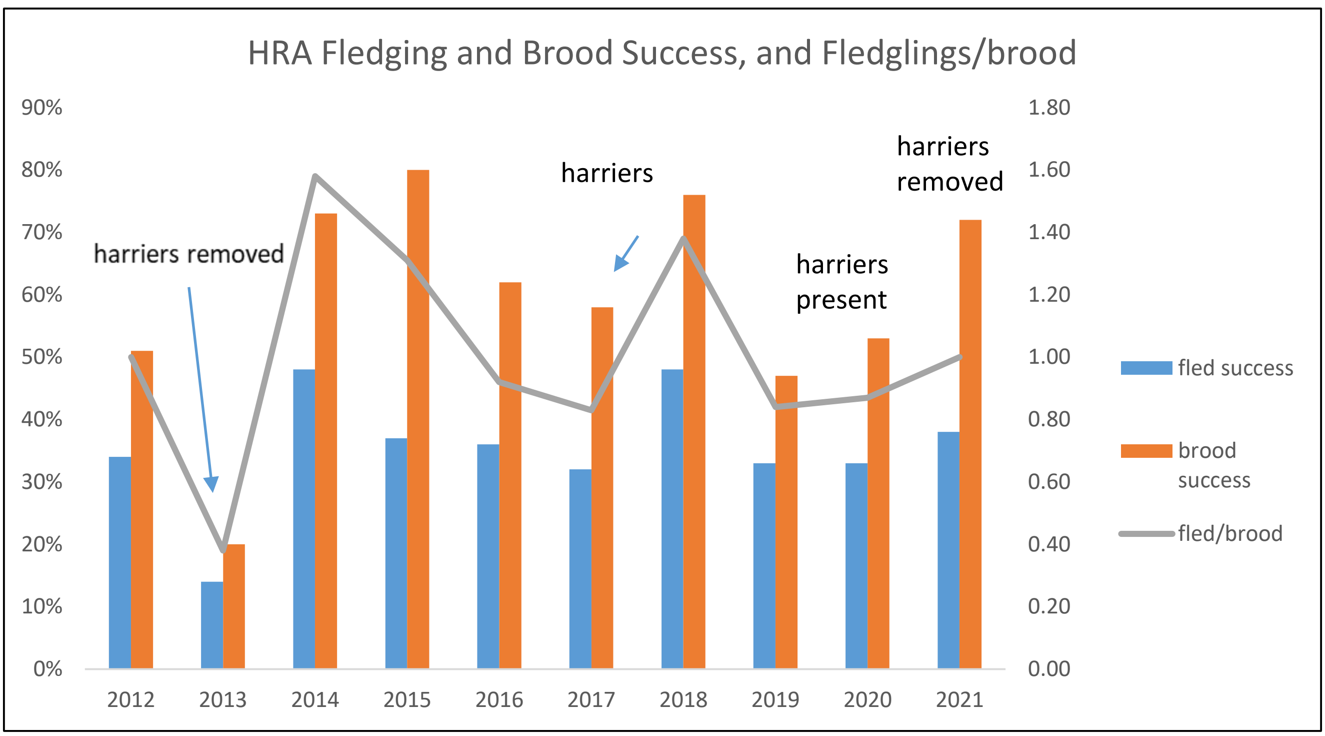

Figure 18. Fledging success, brood success, and fledglings per male for the HRAs at Coos Bay North Spit, 2012-2021. Fledging and brood success are on left axis, fledglings/brood is on right axis. Northern Harriers were removed in 2013, 2017, and 2021. Reproductive parameters improved after harrier removal.

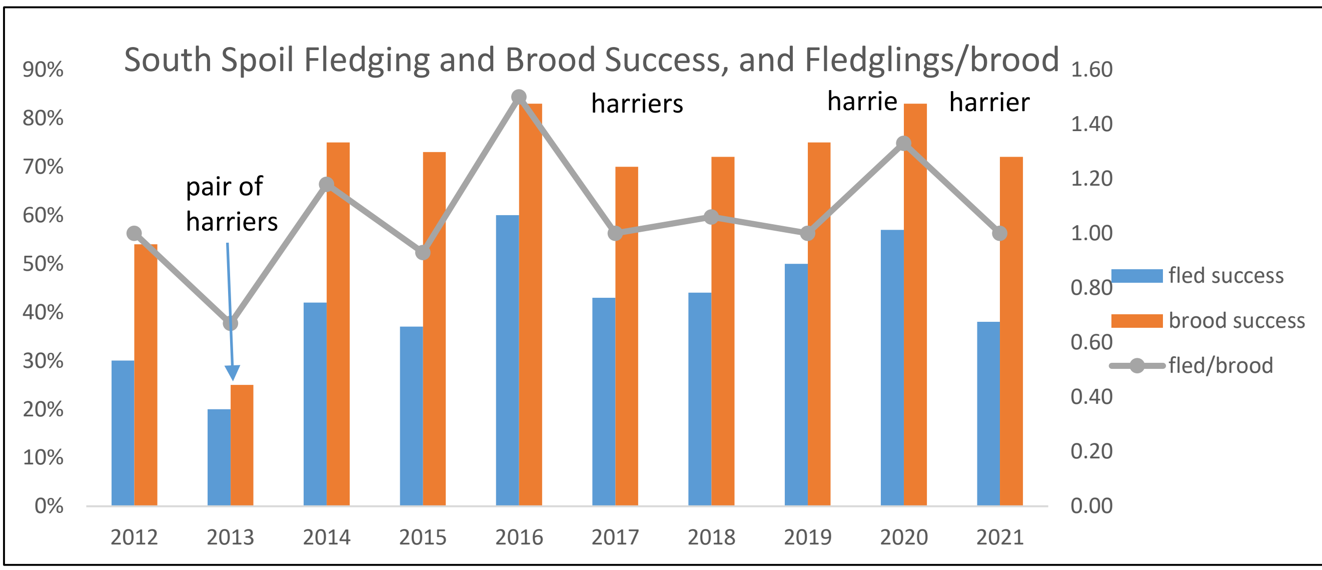

Figure 19. Fledging success, brood success, and fledglings per male for South Spoil at Coos Bay North Spit, 2012-2021. Fledging and brood success are on left axis, fledglings/brood is on right axis. Northern Harriers were removed in 2013, 2017, and 2021. Reproductive parameters improved after harrier removal.

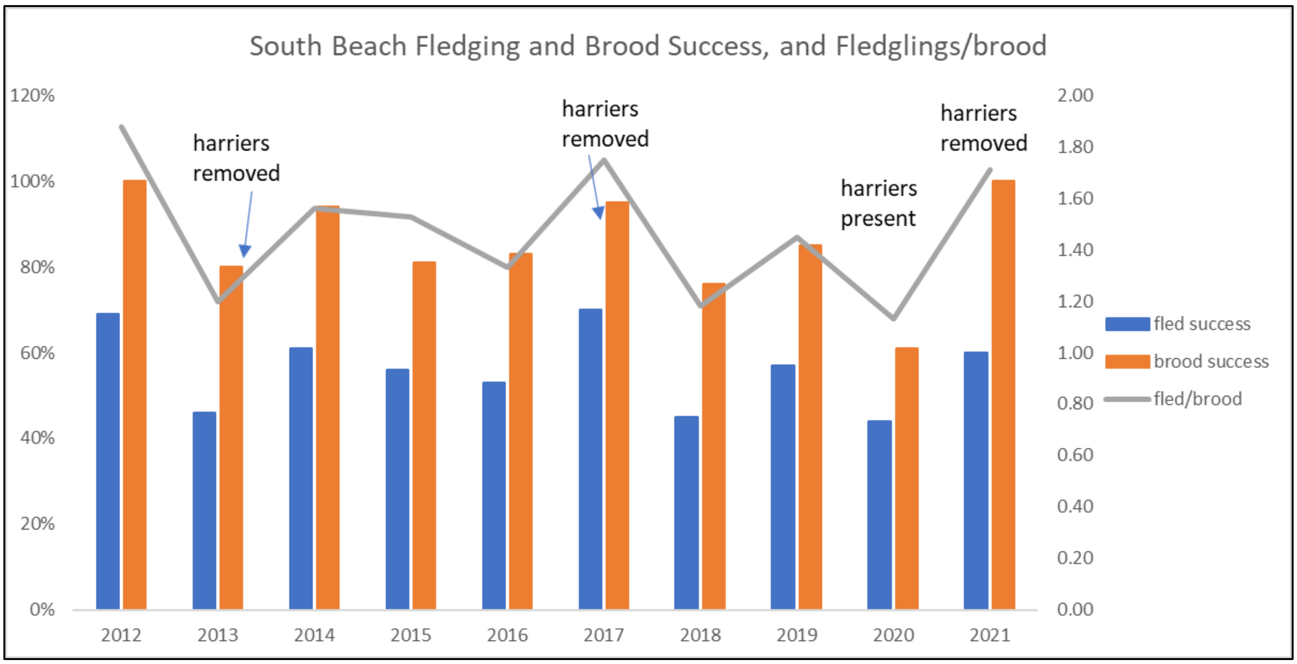

Figure 20. Fledging success, brood success, and fledglings per male for South Beach at Coos Bay North Spit, 2012-2021. Fledging and brood success are on left axis, fledglings/brood is on right axis. Northern Harriers were removed in 2013, 2017, and 2021. Reproductive parameters are not as impacted by harriers on South Beach.

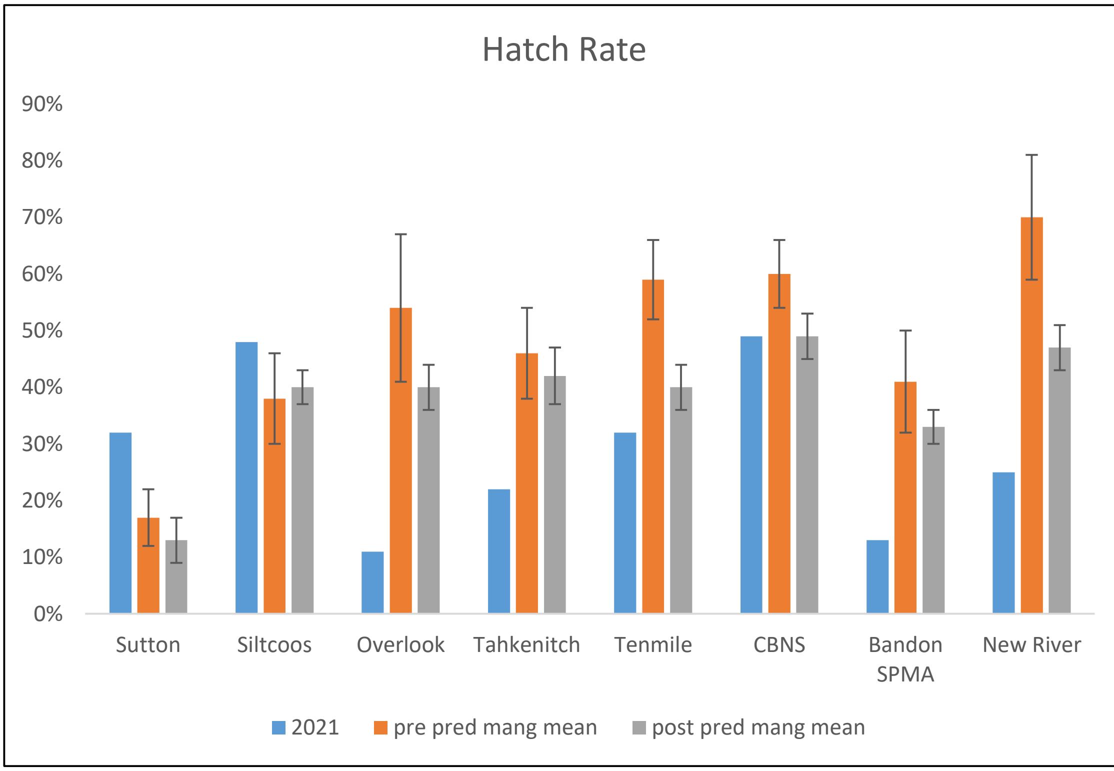

Figure 21. 2021 hatch rate, mean pre predator management hatch rate, and mean post predator management hatch rate for Sutton, Siltcoos, Overlook, Tahkenitch, Tenmile, CBNS, Bandon SPMA and New River, Oregon coast, with standard error bars.

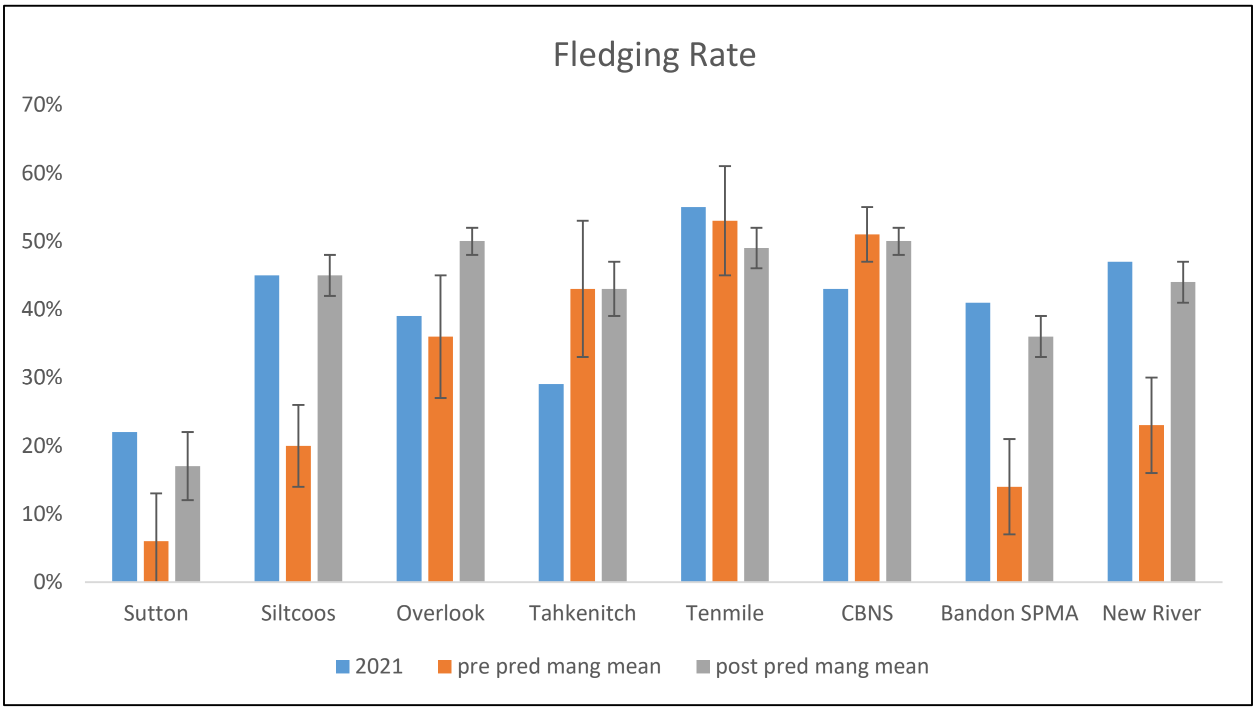

Figure 22. 2021 fledge rate, mean pre predator management fledge rate, and mean post predator management fledge rate for Sutton, Siltcoos, Overlook, Tahkenitch, Tenmile, CBNS, Bandon SPMA and New River, Oregon coast, with standard error bars.

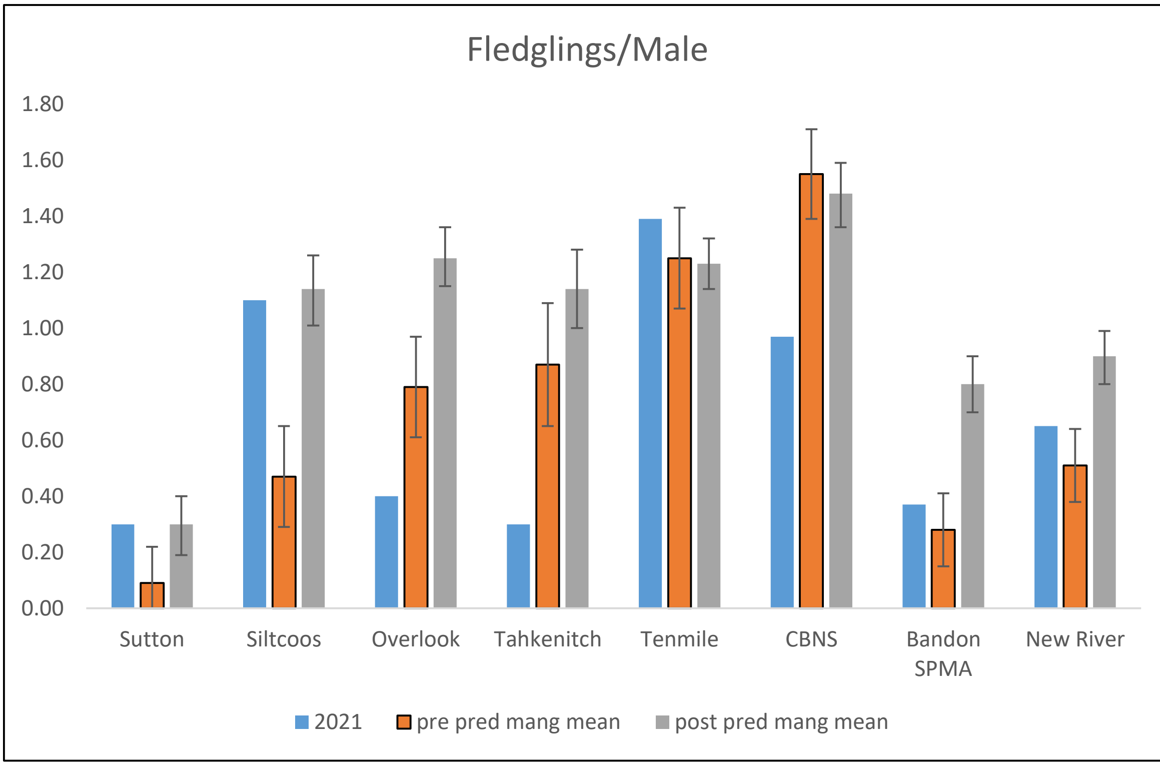

Figure 23. 2021 fledglings per male, mean pre predator management fledglings per male, and post predator management fledglings per male for Sutton, Siltcoos, Overlook, Tahkenitch, Tenmile, CBNS, Bandon SPMA and New River, Oregon coast, with standard error bars.

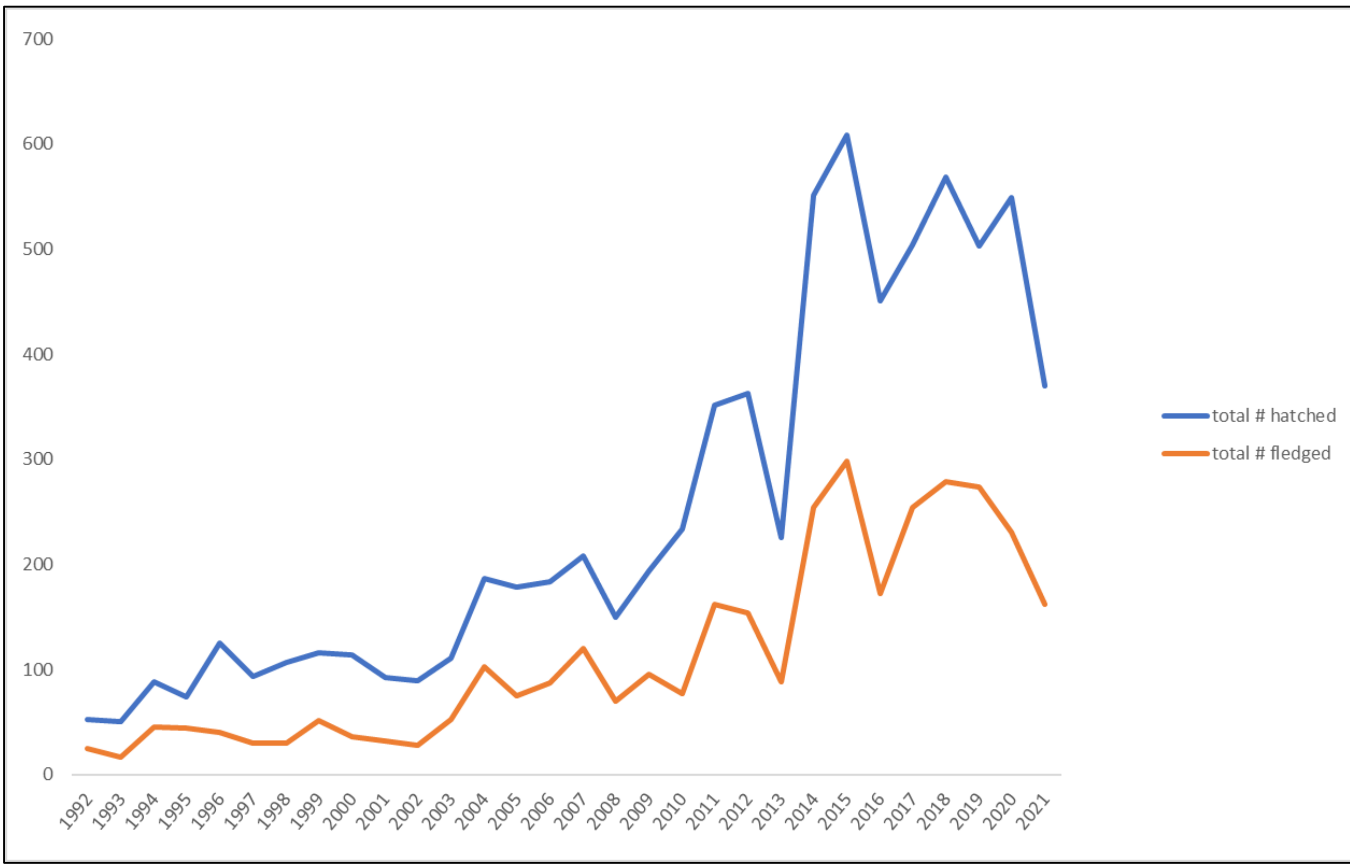

Figure 24. The number of eggs hatched and the number of fledglings on the Oregon coast, 1992-2021.

APPENDIX A.

Study Area

The study area encompassed traditional nesting areas along the Oregon coast including all sites between Berry Creek, Lane Co., and Floras Lake, Curry Co. (Fig. 1). Survey effort was concentrated at the following sites, listed from north to south:

Sutton Beach, Lane Co. (Figure 2). The beach north of Berry Creek south to the mouth of Sutton Creek.

Siltcoos: North Siltcoos, Lane Co. (Figure 3). The north spit, beach, and open sand areas between Siltcoos River mouth and the parking lot entrance at the end of the paved road on the north side of the Siltcoos River; and South Siltcoos, Lane Co. - the south spit, beach, and open sand areas between Siltcoos River mouth and south to Carter Lake trail beach entrance.

Dunes Overlook Clearing, Douglas Co. (Figures 4 and 5). The area directly west of the Oregon Dunes Overlook off of Hwy 101 including the beach from Carter Lake trail to the north clearing, and south to the Overlook trail south of the south clearing.

Tahkenitch Creek, Douglas Co. (Figures 6 and 7) Tahkenitch North Spit - the spit and beach on the north side of Tahkenitch Creek including the beach north to Overlook trail; and South Tahkenitch – from the south side of Tahkenitch Creek to south of Threemile Creek north of the north Umpqua River jetty.

Tenmile: North Tenmile, Coos and Douglas Cos. (Figures 8 & 9). The spit and ocean beach north of Tenmile Creek, north to the Umpqua River jetty; and South Tenmile, Coos Co. The south spit, beach, and estuary areas within the Tenmile Estuary vehicle closure, and continuing south of the closure for approximately 1/2 mile.

Coos Bay North Spit (CBNS), Coos Co. (Figures 10 & 11): South Beach - the beach from the north jetty north to the Horsfall area; and South Spoil/HRAs - the south dredge spoil and adjacent habitat restoration areas (94HRA, 95HRA, 98HRA).

Bandon Snowy Plover Management Area, Coos Co. (Figures 12 & 13): This site includes the Bandon SPMA and all nesting areas from north of China Creek to the south end of state land south of the mouth of New River.

New River, Coos Co. (Figure 14): The privately owned beach and sand spit south of Bandon Snowy Plover Management Area south to BLM lands, and the BLM Storm Ranch Area of Critical Environmental Concern habitat restoration area (HRA).

Floras Lake, Curry Co. (Figure 15). The beach and overwash areas west of the confluence of Floras Creek and the beginning of New River, north to Hansen Breach.

The following additional areas were either surveyed in early spring or the breeding window survey: Clatsop Spit, Necanicum Spit, Nehalem Spit, Bayocean Spit, Netarts Spit, Sand Lake South Spit, Nestucca Spit, Whiskey Run to Coquille River, Sixes River South Spit, Elk River, Euchre Creek, and Pistol River.

APPENDIX B

Snowy Plover Monitoring Methods

Nest Surveys

Monitoring began the first week in April and continued until all broods fledged, typically by mid-September. We used three teams of biologists; one two-person team covering Tahkenitch and sites north, one person covering Tenmile, and a two-person team covering Coos Bay North Spit and sites south (Fig. 1). In some years this division has been modified to accommodate staff needs. All data collected in the field was recorded in field notebooks and later transferred onto computer. Surveys were completed on foot and from an all-terrain vehicle (ATV). Data recorded on nest surveys included:

- site name
- weather conditions
- start time and stop time
- direction of survey
- number of plovers seen, broken down by age and sex
- band combinations observed
- potential predators or tracks observed
- violations/human disturbance observed

Weekly surveys were attempted, but were not always possible due to increasing workload associated with an increased plover population. Additional visits were made to check nests, band chicks, or monitor broods.

Population Estimation

We estimated the number of Snowy Plovers in the project area by counting the number of individually color banded adult Snowy Plovers recorded during the breeding season, and then adding an estimated number of unbanded Snowy Plovers. To arrive at an estimate of the number of unbanded birds present, we counted the number of unbanded birds recorded during each 10-day interval across all sites. We selected the 10-day interval with the highest number of unbanded adults and subtracted the number of unbanded adults that were captured and banded during the breeding season. We added this minimum number of unbanded adults present to the count of banded adults to arrive at the minimum number of adults present during the breeding season. We also determined the number of plovers known to have nested at the study sites, including marked birds and a conservative minimum estimate of the number of unbanded plovers.

Nest Monitoring

We located nests using methods described by Page *et al.* (1985) and Stern *et al.* (1990). We found nests by scoping for incubating plovers, and by watching for female plovers that appeared to have been flushed off a nest. We also used tracks to identify potential nesting areas. We defined a nest as a nest bowl or scrape with eggs or tangible evidence of eggs in the bowl, i.e. egg shells. We predicted hatching dates by floating eggs (Westerskov 1950) and used a schedule, developed by G. Page based on a 29-day incubation period (Gary Page, pers. comm.). We attempted to monitor nests once a week at minimum. We checked nests more frequently as the expected date of hatching approached. We defined a successful nest as one that hatched at least one egg. A failed nest was one where we found buried or abandoned eggs, infertile eggs, depredated eggs, signs of depredation (e.g. mammalian or avian tracks or eggshell remains not typical of hatched eggs or nest cup disturbance) or eggs disappeared prior to the expected hatch date and were presumed to have been predated. In some instances, we found nests with only one egg; often there was no indication of incubation or nest defense, and it was uncertain to what extent the nest was abandoned, or simply a “dropped” egg. Because it was difficult to make this determination, we considered all one egg clutches as nest attempts, and classified them as abandoned when there was no indication of incubation or nest defense. Data recorded at nest checks included:

- nest number
- number of eggs in nest
- adult behavior
- description of area immediately around nest
- whether or not the nest is exclosed
- GPS location

Brood Monitoring

We monitored broods during surveys and other field work, and recorded brood activity or males exhibiting brood defense behavior at each site. “Broody” males will feign injury, run away quickly or erratically, fly around and/or vocalize in order to distract a potential threat to his chicks. Information recorded when broods were detected included:

- Number of adults and chicks
- Band combinations of adults/chicks seen
- Sex of adults
- Behavior of adults
- Brood location

See Appendix C for information on brood sampling in 2016 and later years.

Banding

Adults were normally trapped for banding on the nest, during incubation, using a lily pad trap and noose carpets. Lilly pad traps are small circular traps made of hardware cloth with a blueberry net top. The traps have a small door that the plover will enter. Noose carpets are 4” x 30” lengths of hardware cloth covered with small fishing line nooses. Plovers walk over the carpets and the nooses snag their legs. We limited attempts to capture adults to 20 minutes per trapping attempt. Chicks were captured for banding by hand, usually in the nest bowl. Banding was completed in teams of two to minimize time at the nest and disturbance to the plovers. As the Oregon plover population has grown, it has become impossible to band all broods. In 2016 we attempted to band approximately 80% of broods, spread over all sites and across the nesting season, and in 2021 we reduced the number of sampled broods to approximately 50%. See Appendix C for brood sampling methods.

Adults were banded with a four-band combination of a USFWS aluminum band covered with colored taped and colored plastic bands. We banded broods with a brood-specific two-band combination of USFWS aluminum band covered in colored taped on the left leg and a colored plastic band on the right leg.

APPENDIX C.

Sampling Plan for Banding– Oregon – 2021

Statement of problem:

Prior to 2016, Oregon Snowy Plover monitors attempted to band all chicks, to allow accurate estimates of number of chicks fledged per male at each site. As the population has grown this has become impossible with existing staff because of limited time and limited band combinations. Banding chicks at the nest is time-intensive because it often requires multiple visits as the anticipated hatch date approaches. Point Blue experienced the same problems at sites they monitor. Thus, ORBIC worked with Lynne Stenzel at Point Blue Conservation Science and Laird Henkel at California Department of Fish and Game to develop a plan to band a spatially and temporally representative sample of broods starting in 2016.

Lauten *et al*., (2016, 2017, 2018, 2019, and 2020) documents efforts to sample approximately 80% of monitored broods. Continued increases in the plover population, as well as staff and workload limitations, made this goal unreachable by 2021. For the 2021 field season we worked with Point Blue Conservation Science to further adjust the sampling plan to provide adequate productivity information (Lynne Stenzel, pers. comm.). Sampling techniques remained the same except for a reduction in the percentage of broods sampled, and a reduction in the number of sites that would have sampled broods.

2021 Brood sampling plan:

Plover productivity is a function of nest success (percent of nests that hatch at least one egg) and fledging success (percent of chicks that survive at least 28 days). We identify nest success by determining the fate of all known nests (see Appendix B). In reality, a small proportion of nests are not located each year, but under this plan we will continue to attempt to locate all nests. This intensive effort to locate nests informs adult population estimates and allows us to provide land management agencies and Wildlife Services with timely information on nest predation.

Starting in 2016 (Lauten *et al*., 2016), we modified our field methods (see Appendix B) to limit banding and brood tracking to a spatially and temporally representative subset of broods. We used this sample of broods to identify fledging success and chicks fledged per male.

From 2016 to 2020 we addressed site variation in fledging success (Dinsmore *et al*. 2017) by sampling broods from all currently occupied nesting sites in the project area. We incorporated potential temporal variation in fledging success by banding across the season, dividing the nesting season into 15 10-day periods (Table C-1). Other plover populations exhibit seasonal variation in survival to fledging (Colwell *et al*. 2007, Brudney *et al*. 2013, Saunders *et al*. 2014, Catlin *et al*. 2015). We have not documented this in Oregon (Dinsmore *et al*. 2017), but a 10-day interval allows us to collect data that will be comparable with sampling being done in Recovery Unit 3 (Lynne Stenzel, pers. comm.).

For each 10-day period, at each site, we:

- Attempted to locate all nests.
- Estimated hatch date for all known nests based on number of eggs in nest when found, or by floating eggs (Westerskov 1950, Hays and LeCroy 1971, Dunn et al. 1979, Rizzolo and Schmutz 2007, Gary Page personal communication).
- Recorded fate of all known nests.
- Color banded all chicks from a sample of hatched nests. Our sample consisted of the first 5 known nests to hatch at each site in a given 10-day period (Table C-1). At sites with fewer than 5 hatched nests during an interval,

we banded all broods from known nests (but see next bullet point). At sites with more than 5 hatched nests during an interval, we banded all chicks from the first 5 known nests that hatched. As in previous years, chicks did not receive unique color combinations; instead we used brood-specific combinations. Each chick received a USGS metal band wrapped with a brood-specific color tape combination on the left leg and a color band on the right leg (see Appendix B).

- Broods from undiscovered nests that were not banded, were not included as part of the sample, and were not included in productivity estimates for the site. If a brood from an undiscovered nest was found and captured with all three chicks, this brood was used in the productivity calculations.
- Broods were selected for sampling based on actual hatch date, not on expected hatch date.
- If we incorrectly estimated the expected hatch date of a known nest, and the brood was out of the nest before we were able to band it, we skipped that brood and banded the next brood that hatched, up to a total of 5 broods per site per 10-day interval.
- Conducted approximately weekly surveys to relocate banded broods during the fledging period. Banded chicks observed were recorded, but status of very young broods was also confirmed based on adult behavior. As broods approached fledging age, we increased effort to count individual chicks. Chicks observed at or after 28 days after hatching were considered fledged (Warriner et al. 1986).

The banded sample of broods and their attending male was used to report brood success, fledging success, and to calculate the number of fledglings per sampled brood. The banded sample of chicks that fledged was multiplied by a weighting factor (total broods/broods sampled) to give an estimated number of chicks fledged per site. The number of fledglings per male was then calculated from the estimated number of fledglings and the number of resident males for each site and overall. For 2021, we continue to follow the basic outline of the sampling technique, except we reduced the percentage of sampled broods from 80% to 50%. We also did not sample any broods with banding techniques at Sutton Beach, South Tahkenitch to North Umpqua, South Tenmile, and New River private lands. At Sutton Beach and Floras Lake, small numbers of broods from successful nests were sufficiently monitored without banding to use for sample calculations.

Table C-1. Ten-day intervals used to determine brood sample. Within each interval, the first five hatched broods were banded and tracked to fledging.

Ten day intervals	Interval number
April 1 - April 10	1
April 11 - April 20	2
April 21 - April 30	3
May 1 - May 10	4
May 11-May 20	5
May 21 - May 30	6
May 31 - June 9	7
June 10 - June19	8
June 20 - June 29	9
June 30 - July 9	10
July 10 - July 19	11

July 20 - July 29	12
July 30 - August 8	13
August 9 - August 18	14
August 19 - August 28	15

Summary

From 2016 to 2020 the sampling plan resulted in sufficient estimates of productivity (Lauten *et al*., 2016, 2017, 2018, 2019, and 2020). The Oregon Snowy Plover population has continued to increase (Lauten *et al*., 2020). The reduction in sampling effort will result in a lower percentage of hatched nests being sampled, and will increase variability estimates. However, we believe the estimates will be sufficient to estimate productivity while alleviating workload.

Using the sample to estimate plover productivity

Using the sample, we calculated brood success for each site (the number of broods that successfully fledged at least one chick). Based on the number of eggs and fledglings counted from the sample, we calculate fledging success for each site (the number of chicks fledged/the number of eggs laid). In order to determine fledglings per male for each site and the entire project area, we treated each sampled brood as an independent unit and used the sample to calculate the estimated fledglings per sampled brood. Not all males on each site are sampled. To estimate the number of breeding males for each site, we use the survey data to determine how many males were resident at each site. Males were considered resident if they were present at a site between 15 April and 15 July and therefore had an opportunity to attempt to nest. Using the number of fledglings produced per sampled brood, we calculated an estimated number of fledglings produced for all broods at each site:

$$f_{sy} * k_y = E_y$$

where f_{sy}= the number of fledglings per sample brood at site y; k_y = total number of known broods at site y; and E_y = the estimated number of fledglings for site y.

We then divided E_y by the number of resident males for site y (R_y):

$$\frac{E_y}{R_y} = F_y$$

So that F_y is the estimated number of fledglings produced per male for site y.

We calculated the estimated number of fledglings per male for each site. Since males can and do roam between sites, and can breed at more than one site in a given year, to estimate fledglings per male for the project area, we determined the total number of resident males within the project area, and divided that by the estimated number of fledglings produced for all known broods. We calculated a mean number of fledglings per male from all sites, and display the mean with the standard deviation (Table 12).